Deliverable Phase 2 – Climate risk assessment

REGMURCIA CLIMAAX

Region of Murcia, Spain

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Document Information

Deliverable Title	Phase 2 – Climate risk assessment
Brief Description	Deliverable 2 refines the Phase 1 Climate Risk and Vulnerability Assessment for the Region of Murcia by improving the analysis of the priority hazards identified in D1: agricultural droughts, river flooding, coastal flooding and heatwaves. It incorporates higher-resolution regional, national and local data, and combines technical results with stakeholder validation. For agricultural droughts, the assessment replaces generic global assumptions with regional evidence on crop production, crop surfaces, crop types and rainfed agricultural land, producing a more coherent estimate of expected losses. For river flooding, it compares European datasets from the CLIMAAX Toolbox with Spanish national and regional sources to assess how hazard maps, exposure data and damage functions influence loss estimates. For coastal flooding, D2 develops a new sea-level-rise and damage assessment using high-resolution elevation data, hydraulic-connectivity modelling and municipality-level estimates. The heatwave analysis is maintained from Phase 1 but enriched with stakeholder input. A key contribution of D2 is the integration of stakeholder evidence through a revised Delphi-informed consultation process, a survey with 67 responses and semi-structured interviews. These inputs help assess perceived severity, urgency, resilience capacity, adaptation priorities, governance barriers and implementation gaps. The deliverable concludes with an integrated Key Risk Assessment. Agricultural droughts and heatwaves remain very high priority risks, river/pluvial flooding is upgraded to very high priority, and coastal flooding and erosion emerge as a high strategic priority for coastal planning, tourism, the Mar Menor and long-term sea-level-rise adaptation. The results will support Phase 3, focused on sectoral technical tables, co-design of adaptation measures, governance agreements and the translation of climate-risk evidence into planning and implementation.
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Leading Institution	Regional Secretary of Energy, Sustainability and Climate Action (CARM)
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Abbreviations and acronyms

Abbreviation / acronym	Description
CARM	Comunidad Autónoma de la Región de Murcia (Regional Government of the Region of Murcia)
CLIMAAX	CLIMAte risk and vulnerability Assessment framework and toolboX
CNIG	Centro Nacional de Información Geográfica (Spanish National Centre for Geographic Information)
CRA	Climate Risk Assessment
DANA	Depresión Aislada en Niveles Altos (cut-off low-pressure system associated with intense, localised rainfall episodes in Spain)
DEM	Digital Elevation Model
EAD	Expected Annual Damage
FSTP	Financial Support to Third Parties
GTSM	Global Tide and Surge Model
JRC	Joint Research Centre of the European Commission
KPI	Key Performance Indicator
LUISA	Land-Use-based Integrated Sustainability Assessment (JRC territorial modelling platform)
RCP	Representative Concentration Pathway
RP	Return Period
SIOSE	Sistema de Información de Ocupación del Suelo de España (Spanish Land-Use/Land-Cover Information System)
UMU	Universidad de Murcia (University of Murcia)

Executive summary

This deliverable (D2) presents the second-phase Climate Risk Assessment (CRA) for the Region of Murcia (REGMURCIA), developed under the Financial Support to Third Parties (FSTP) cascade-grant mechanism of the Horizon Europe CLIMAAX project. The first-phase deliverable (D1, submitted in September 2025) applied the standard CLIMAAX Toolbox to three hazards selected for the region – river and coastal floods, agricultural/relative drought, and heatwaves – using harmonised, pan-European datasets such as the Joint Research Centre (JRC) flood hazard maps, the LUISA land-use projections, the Global Tide and Surge Model (GTSM), and global digital elevation models. This second phase tests and refines those Phase 1 results against finer-resolution regional and national data, and against the direct experience of regional and local stakeholders, with the explicit aim of identifying where, and why, results obtained with coarse European datasets diverge from those obtained with higher-resolution local sources. Because river flooding and coastal flooding are deepened in this phase through two separate hazard and damage models (Section 2.3.2), this deliverable treats them from Section 2.2 onward as two distinct hazards within REGMURCIA's portfolio – four in total, alongside agricultural drought and heatwave – rather than as the single combined hazard referenced above for continuity with Phase 1's original framing.

When considering river and coastal flood risk, this Phase 2 analysis applies the open-source DamageScanner library with Huizinga et al. (2017) depth-damage curves — an independent, peer-reviewed alternative to the generic JRC default damage curves used natively by the CLIMAAX Toolbox in Phase 1 — to four combinations of flood-hazard source (JRC versus the Spanish Centro Nacional de Información Geográfica, CNIG) and land-use source (LUISA versus the Spanish Sistema de Información de Ocupación del Suelo de España, SIOSE), all clipped to the administrative boundary of the Region of Murcia and homogenised to a common 50 m resolution. The resulting river-flood damage estimates – ranging, depending on the combination, from approximately €620 million to €1,690 million at the 10-year return period and from approximately €1,475 million to over €10,380 million at the 500-year return period – are, for the combination most directly comparable to Phase 1 (JRC hazard maps with LUISA land-use), substantially lower than Phase 1's region-wide estimate (€7,614 million at RP10 to €11,100 million at RP500). Section 2.3 of this deliverable examines this divergence in detail; the most plausible contributing factors identified include the differing treatment of depth-damage curves, differences in spatial domain and resolution handling, and the choice of hazard-source dataset itself, which this analysis's own internal comparison identifies as a far stronger driver of total damage than the choice of land-use dataset. Notably, Phase 1's region-wide figures sit closer in magnitude to this analysis's national-hazard-source (CNIG) combinations than to its nominally equivalent European-hazard-source (JRC) combination – a finding that calls for cautious interpretation rather than a definitive reconciliation, since several methodological differences between them remain unresolved.

Coastal flooding is addressed through a separate high-resolution sea-level-rise and damage model developed with the Universidad de Murcia (Section 2.3.2). Unlike D1, which did not provide a directly comparable coastal euro-damage baseline, D2 generates municipality-level estimates using a 5 m digital elevation model, hydraulic-connectivity modelling, a continuous sea-level-rise sweep from 0 to 100 cm, and a damage function validated against local evidence from the September 2019 Los Alcázares flood. The new analysis identifies municipality-specific critical heights at which flooded area increases abruptly, including approximately 37 cm and 65 cm of sea-level rise for San Pedro del Pinatar. It also shows that Cartagena and San Javier are the two municipalities with the largest projected coastal losses, each approaching €450 million at the upper end of the sea-level-rise range. Coastal flooding is therefore spatially concentrated, but strategically important, especially for coastal planning, tourism, the Mar Menor, exposed developable land and long-term land-use decisions.

Agricultural/relative drought also receives a major methodological update in this phase (Section 2.3.1). In contrast to Phase 1, where the use of global crop-exposure and generic vulnerability datasets produced important inconsistencies for the Region of Murcia, D2 updates the drought workflow using higher-resolution regional evidence on real agricultural production, official crop surfaces, crop types and rainfed agricultural land in the CARM. The revised workflow incorporates FAO-56 dual crop-coefficient and yield-response parameters for seven rainfed crops — barley, oats, wheat, olive, almond, wine grapes and pistachios — together with ESAM-sourced production and price records and a SIGPAC/CREM spatial exposure layer for rainfed agriculture. This updated evidence base covers more than 500,000 SIGPAC parcels and approximately 316,985 ha of rainfed agricultural land, including around 139,593 ha of arable land, 86,929 ha of tree nuts, 18,885 ha of olive groves and 15,730 ha of vineyards. It also uses crop-specific production and value data, including indicative exposure values of approximately €123.38 million for almond, €52.82 million for olive, €44.73 million for wine grapes, €7.50 million for barley, €4.42 million for oats, €3.40 million for wheat and €2.44 million for pistachios. These inputs allow D2 to provide more coherent expected-loss estimates for rainfed agriculture than those obtained in Phase 1, especially for crops and systems that are highly relevant in the regional context. Agricultural drought is therefore not treated only as an exposure-data improvement, but as a substantially updated workflow that strengthens the reliability of the CRA for agricultural and territorial adaptation planning.

The heatwave workflow is carried forward from Phase 1 without a comparable quantitative re-run in D2 (Section 2.3.3). This does not mean that heatwave risk is considered less relevant, nor simply that no data exist. Rather, the Phase 1 heatwave workflow did not reveal the same level of internal inconsistency or methodological divergence identified for the flood and drought workflows, where the comparison between European-scale and regional/national evidence produced major differences. Heatwaves remain a very high priority risk for the Region of Murcia, based on the Phase 1 evidence on increasing heatwave frequency, population exposure and vulnerable age groups. D1 projected heatwave frequency to rise from approximately 3 events per year at baseline to more than 50 events per year by late century under RCP8.5, with interior counties seeing an approximately tenfold increase and southern coastal counties an approximately eightfold increase. D1 also cited recent evidence of severe heat impacts, including 22 heat-related deaths in Murcia in summer 2025. Phase 2 complements this technical baseline with stakeholder evidence, which confirms that heatwaves are perceived as a social, health, labour, urban and public-facility risk affecting care homes, schools, outdoor workers, tourism, agriculture and urban liveability.

Stakeholder engagement was a major component of Phase 2 (Sections 2.1.5 and 2.4.7). The process included a Delphi-informed review of the consultation instruments, a quantitative stakeholder survey with 67 response records, and semi-structured interviews with nine regional and local stakeholders spanning agricultural research (IMIDA), social-services infrastructure (DG IMAS), agri-food policy and agricultural insurance (DG Industria Alimentaria y Asociacionismo Agrario), territorial planning (Dirección General de Ordenación del Territorio y Arquitectura), the agricultural cooperative sector (FECOAM), regional meteorology (AMETSE), municipal climate action (Agencia Local de la Energía y Cambio Climático, Ayuntamiento de Murcia), tourism (ITREM), and environmental advocacy (Ecologistas en Acción Región de Murcia). Eight of these interviews were incorporated into the present analysis; the last closed shortly before submission and will be addressed in a subsequent update.

The survey confirms very high recognition of climate change among regional stakeholders: 63 of the 67 response records, equivalent to 94%, state that climate change is a reality. It also shows strong support for adaptation measures across all hazard families, with average scores above 4.4 on a 1–5 scale for river/pluvial flooding, coastal flooding and sea-level rise, heatwaves, and drought/water scarcity. Heatwaves obtain the highest overall adaptation-priority score, closely followed by river/pluvial flooding and drought/water scarcity. At the same time, the survey identifies a clear implementation gap: only 12 response records indicate the existence of a specific budget for climate adaptation, while 24 report no specific budget and 30 select “do not know / no answer”. Monitoring and evaluation of adaptation actions also remain weak, with mean frequency scores generally between 2.1 and 2.6 on a 1–5 scale.

The interviews add sectoral and institutional depth to these findings. Floods and extreme heat were raised frequently, often anchored to the October 2024 Valencia DANA as a shared point of reference. Drought was framed as a structurally important risk for agriculture and dryland territorial viability. Institutional fragmentation, slow procurement and licensing procedures, insufficient funding, lack of technical staff and difficulties in translating diagnosis into executable measures recurred as cross-cutting barriers to adaptation across the interviews. A consistent request across stakeholders was for CLIMAAX outputs to be operational and accessible to non-specialists — municipal technicians, elected officials and the public — rather than remaining purely technical products.

The integrated Key Risk Assessment comparison combines three evidence streams: the Phase 1 preliminary prioritisation, the refined Phase 2 workflow evidence and the stakeholder-based assessment (Sections 2.4.6–2.4.8). Agricultural droughts remain a very high priority risk, now supported by a more coherent regional loss assessment for rainfed agriculture. Heatwaves also remain very high priority, supported by the Phase 1 hazard evidence and strong stakeholder validation. River/pluvial flooding is the clearest upward revision, moving from high priority in Phase 1 to very high priority in Phase 2 and in the stakeholder-based assessment. Coastal flooding and erosion remain less region-wide than drought, heatwaves and river/pluvial flooding, but the refined coastal modelling and stakeholder evidence support treating them as a high strategic priority for coastal municipalities, tourism, the Mar Menor and future planning.

Overall, this phase confirms the continued relevance of the hazards prioritised in Phase 1 while showing that the quality and resolution of hazard, exposure and vulnerability data can substantially affect the interpretation of risk. For river flooding, the flood-hazard source is identified as a dominant driver of sensitivity in damage estimates. For agricultural drought, the use of real regional production, crop-surface and rainfed land-use data provides a more coherent basis for expected-loss estimation. For coastal flooding, high-resolution local modelling reveals non-linear exposure thresholds that were not visible in the coarser Phase 1 approach. For heatwaves, the Phase 1 assessment remains methodologically usable and is strongly reinforced by stakeholder evidence.

The main cross-cutting conclusion is that the limiting factor is not low risk perception. Stakeholders perceive the main risks as substantial to critical and highly urgent. The main weakness lies in resilience and implementation capacity: institutional fragmentation, administrative slowness, insufficient funding, lack of technical staff, uneven data integration, weak monitoring and difficulties in translating climate-risk evidence into executable measures. Phase 3 should therefore focus on sectoral technical working tables, agreement-building and the co-design of feasible adaptation pathways, linking each priority risk with responsible institutions, funding routes, monitoring indicators and practical implementation conditions.

1 Introduction

1.1 Background

The Region of Murcia is a Mediterranean region in the southeast of the Iberian Peninsula, covering approximately 11,300 km² and home to around 1.5 million inhabitants. Its economy relies heavily on agriculture, the agri-food industry, tourism, and increasingly on renewable energy and logistics, all of which are sensitive to climate-related impacts on water availability, coastal integrity, and infrastructure resilience. As one of the most arid regions in Europe, Murcia is characterised by a semi-arid Mediterranean climate with high interannual rainfall variability and recurrent drought, while flash floods and heatwaves represent the most acute hydrometeorological hazards affecting the population, agriculture, and critical infrastructure. A fuller socioeconomic and climatic characterisation of the region is provided in the Phase 1 deliverable (D1) and is not repeated here.

1.2 Main objectives of the project

Phase 2 of REGMURCIA CLIMAAX addresses the regionalised refinement of the Phase 1 risk assessment. Its main objectives are to:

1. Deepen the risk assessment using locally and nationally sourced hazard and exposure data, complementing the European-scale datasets used in Phase 1.
2. Compare the resulting damage estimates against the Phase 1 results and identify the methodological factors that explain the differences between them.
3. Broaden stakeholder engagement beyond Phase 1 through a Delphi-informed review of the consultation instruments, a quantitative stakeholder survey and semi-structured interviews with regional and local actors, in order to validate hazard prioritisation, interpret severity, urgency and resilience capacity, and identify adaptation barriers, governance gaps and implementation needs.
4. Identify remaining data and engagement gaps to be addressed in Phase 3.

The CLIMAAX Handbook continues to provide the standardised methodology underpinning this phase, ensuring consistency with Phase 1 and comparability with other CLIMAAX regions. The incorporation of local and national data sources and models – the Centro Nacional de Información Geográfica (CNIG) flood hazard maps, the Sistema de Información de Ocupación del Suelo de España (SIOSE) land-use layers, and direct stakeholder testimony – allows Phase 1 results to be tested against finer-resolution, region-specific evidence, strengthening the credibility of the assessment for regional decision-makers while remaining traceable to the harmonised CLIMAAX framework. For the Region of Murcia, this matters in practice: sharper, locally grounded risk evidence gives municipalities and the regional government a firmer basis for prioritising flood-defence and irrigation-efficiency investments under instruments such as the Regional Land-Use Strategy (PORM) and ERDF- or LIFE-funded programmes.

1.3 Project team

The team implementing REGMURCIA CLIMAAX combines the regulatory authority of the CARM with the scientific and technical excellence of the University of Murcia (UMU).

The CARM, through the Regional Secretary of Energy, Sustainability and Climate Action, assumes overall coordination, provides administrative data, and ensures the integration of results into the

ERMACC, its legal framework, and other territorial management plans. UMU is responsible for the full application of the CLIMAAX methodology, the refinement of the assessment using high-resolution climate databases and GIS, advanced modeling of droughts, floods, and heatwaves, as well as the facilitation of technical meetings and the participatory process of the Key Risk Assessment.

The UMU team is made up of experts in Geography and Earth Physics with more than 200 JCR-Q1 publications and regularly collaborates with internationally renowned centers such as NCAR, ETH Zurich, and Yale University. It leverages proprietary tools (CLIMAX, SINQLAIR, COST, 4DROP) and a 1,008-CPU, 1 PB HPC cluster, ensuring rapid calculations and scientific traceability. This partnership ensures a robust climate risk assessment aligned with European standards and backed by the institutional capacity necessary to update and transform it into concrete adaptation measures.

1.4 Outline of the document's structure

This document is organised following the logic of the CLIMAAX framework and reflects the structure and outcomes of the Phase 2 work carried out for the Region of Murcia under the REGMURCIA CLIMAAX project. Chapter 1 introduces the context and scope of this phase: it outlines the regional background (Section 1.1), presents the objectives pursued during Phase 2 (Section 1.2), describes the project team (Section 1.3), and closes with this summary of the document's organisation (Section 1.4).

Chapter 2 (Climate risk assessment – Phase 2) is the core of the deliverable. It follows the steps of the CLIMAAX CRA methodology and, for each step, states explicitly what is new in Phase 2 and what carries over from Phase 1 (D1) rather than repeating the Phase 1 account in full. It is divided into six subsections, each corresponding to a step of the CLIMAAX methodology:

- Section 2.1 – Scoping summarises the Phase-1 scoping outcomes (the project's objectives, context, and stakeholder framework for the three hazards under assessment) and reports how scoping evolved in Phase 2, in particular the deepened stakeholder engagement through a new round of interviews and the explicit statement, for the first time, of the assessment's guiding principles.
- Section 2.2 – Risk Exploration revisits the hazard screening and scenario choice first made in Phase 1. The screening itself — river flooding, coastal flooding, agricultural drought, and heatwaves — is unchanged from Phase 1.
- Section 2.3 – Regionalized Risk Analysis presents the results of the three CLIMAAX workflows applied to the region — Workflow #1 (agricultural droughts), Workflow #2 (coastal and river floods), and Workflow #3 (heatwaves) — together with a fourth subsection (2.3.4) covering the additional analyses based on locally available models and data carried out in this phase: the flood hazard-source comparison, the coastal sea-level-rise damage model and the updated agricultural-drought workflow for rainfed agriculture.
- Section 2.4 – Key Risk Assessment Findings synthesises the outcomes of the risk analysis for each hazard, following the CLIMAAX risk-assessment steps: mode of engagement, gathering of workflow outputs, assessment of severity and urgency, evaluation of resilience capacity, and the resulting risk prioritisation.
- Section 2.5 – Monitoring and Evaluation sets out the framework proposed for tracking progress and evaluating the effectiveness of adaptation actions in subsequent phases.

- Section 2.6 – Work plan for Phase 3 outlines the next steps of the REGMURCIA CLIMAAX project, including validation and operational use of the updated drought results, refinement of heatwave adaptation evidence, and the participatory design of sector-specific adaptation measures through technical working tables.

Chapter 3 (Conclusions Phase 2) summarises the main findings of this phase and their implications for adaptation planning in the Region of Murcia.

Chapter 4 (Progress evaluation) reports on the milestones achieved during Phase 2 and on the key performance indicators defined in the project's Individual Follow-up Plan.

Chapter 5 (Supporting documentation) lists the data sources used, the stakeholder interviews conducted, and the dedicated Phase 2 analyses underpinning this deliverable.

Chapter 6 (References) lists all sources cited throughout the deliverable.

2 Climate risk assessment – phase 2

This section presents REGMURCIA's Phase 2 Climate Risk Assessment, following the steps of the CLIMAAX Framework. Where a step substantially repeats Phase 1, the corresponding subsection states explicitly what, if anything, has changed since the first scoping; the remaining subsections focus on the new analysis carried out in this phase.

2.1 Scoping

The scoping phase for REGMURCIA was first carried out during Phase 1 (Deliverable 1, D1, submitted September 2025) and defined the project's objectives, context and stakeholder framework for all three hazards under assessment (agricultural drought, river and coastal floods, and heatwaves). That framework is not repeated in full here; the reader is referred to D1, Section 2.1, for the complete account. This section summarizes the Phase-1 scoping outcomes and reports how scoping evolved during Phase 2, in which stakeholder engagement was deepened through a Delphi-informed review, a quantitative stakeholder survey and a new round of semi-structured interviews and the assessment's guiding principles are made explicit for the first time.

2.1.1 Objectives

- Objective and purpose. As established in Phase 1 (Section 2.1.1), REGMURCIA's objective is to produce a policy-ready, multi-hazard diagnosis of climate risk for the Region of Murcia that feeds directly into regional and municipal planning instruments (the Regional Land-Use Strategy, PORM; municipal urban plans and building bylaws) and into investment programming (ERDF, LIFE, CAP eco-schemes, NextGenerationEU funds). This objective is unchanged in Phase 2. What changes is the evidentiary detail behind it: Phase 2 concentrates on the hazards for which higher-resolution regional, national or local evidence was available, especially agricultural drought, river flooding and coastal flooding. For agricultural drought, the workflow is updated using regional crop, production, surface and rainfed-exposure data to provide a more coherent estimate of expected losses for rainfed agriculture. For river and coastal flooding, Phase 2 brings in higher-resolution national and local hazard, exposure and damage evidence, including CNIG flood hazard maps, SIOSE land use and a dedicated coastal sea-level-rise model, set alongside the JRC/LUISA layers used in Phase 1.
- Limitations, boundaries and challenges. Phase 1 identified three main limitations affecting the preliminary assessment: the spatial-resolution mismatch between harmonised European datasets and the finer territorial features of the Region of Murcia; the incomplete vulnerability and exposure evidence available for specific sectors, crops, population groups and assets; and the limited availability of downscaled or locally validated climate-risk inputs for some hazards. Phase 2 addresses these limitations selectively, according to the availability of suitable regional, national and local evidence. For river flooding, the main limitation addressed is the mismatch between the European JRC flood-hazard layer used in the CLIMAAX Toolbox and the higher-resolution Spanish national flood mapping available through CNIG/SNCZI. Phase 2 therefore compares JRC and CNIG hazard maps, together with LUISA and SIOSE exposure layers, in order to identify how the choice of hazard and exposure source affects flooded area and estimated economic damage. This does not eliminate all uncertainty, since the damage functions and spatial harmonisation still require further validation, but it directly responds to the resolution and hazard-source limitation identified in

D1. For coastal flooding, Phase 2 addresses the limitations of the coarse and discrete Phase 1 coastal assessment by developing a separate high-resolution sea-level-rise and damage model. The new approach uses a 5 m digital elevation model, hydraulic-connectivity modelling, a continuous sea-level-rise sweep and municipality-level damage estimation. This improves the spatial and planning relevance of the assessment, although the absence of a directly comparable coastal euro-damage baseline in D1 still limits the possibility of a strict like-for-like comparison between phases. For agricultural drought, Phase 2 addresses one of the main weaknesses identified in Phase 1: the use of generic global crop-exposure and vulnerability inputs that were not sufficiently coherent with the agricultural reality of the Region of Murcia. The updated workflow uses regional production and price records, official crop-surface data, crop-specific parameters and spatially explicit rainfed agricultural land information. This allows D2 to provide a more coherent expected-loss assessment for rainfed agriculture. Remaining uncertainties are therefore no longer related to the absence of a revised drought-loss estimate, but to local calibration of crop-specific parameters, validation against observed drought-loss events, future updating of climate inputs, and possible extension to irrigated crops and indirect economic impacts. For heatwaves, Phase 2 does not apply the same level of quantitative re-analysis. This decision should not be interpreted as a lower relevance of heat risk, but as a prioritisation choice within the Phase 2 scope. The Phase 1 heatwave workflow did not show the same level of internal inconsistency or data-source divergence identified for the flood and drought workflows, and was therefore retained as the quantitative baseline. Phase 2 nevertheless strengthens the interpretation of heatwave risk through the stakeholder survey and interviews, especially regarding vulnerable groups, social and health services, public buildings, outdoor work, urban heat and institutional response capacity. The main remaining cross-cutting challenge is therefore not simply data availability, but the integration of refined risk evidence into operational decision-making. Phase 2 reduces several technical limitations identified in D1. The main practical challenge encountered during Phase 2 scoping was scheduling stakeholder interviews within the reporting window: of nine institutions contacted, all nine interviews had been completed by the time of writing, though the last of these closed too close to submission for its findings to be incorporated into the analysis in this deliverable (Section 2.1.5).

2.1.2 Context

- Historical handling of climate hazards. As described in Phase 1, climate-hazard management in the Region of Murcia has historically been reactive rather than anticipatory: civil-protection flood plans and post-event recovery funding, with risk mapping (e.g. INUNCAR) used mainly for emergency response rather than upstream land-use or building-code decisions. Phase 1's own account is more granular per hazard. Regional mean temperature has risen by more than 2°C since 1981, with more frequent tropical nights, prompting a four-level (green/yellow/orange/red) seasonal heat-alert system run jointly with the Ministry of Health (Espín-Sánchez, 2017; Ministerio de Sanidad, 2024). On drought, Murcia has invested since the 1980s in desalination and wastewater reuse, reaching over 90% reuse of treated wastewater and roughly 90% of farmland under drip irrigation (Pérez Morales et al., 2014; Sala-Garrido et al., 2020), even as illegal groundwater extraction and unrepaired network losses persist (Simón and Oller, 2024). On floods, the 2007 Special Civil Protection Plan (INUNMUR) maps flood-prone areas and coordinates emergency response

(CARM and DGPC, 2007), yet nearly 800 critical points remain exposed to intense rainfall (CHS, 2023) and past planning decisions have allowed construction in flood-prone areas (Pérez-Morales et al., 2018); the September 2019 DANA caused seven fatalities and over €1.3 billion in damages (Romero-Díaz and Pérez-Morales, 2021). Coastal flooding is a comparatively newer concern, with sea-level rise and intensified storms projected to erode several stretches of the Murcian coast (CARM, 2019). The eight stakeholder interviews analysed to date for Phase 2 corroborate the overall reactive-rather-than-anticipatory pattern rather than revising it. Public-sector interviewees describe planned retrofitting of vulnerable infrastructure as the exception: DG IMAS reports no systematic, proactive renewal of climate-control equipment in social-care facilities, and the Local Energy and Climate Change Agency (Ayto. Murcia) cites slow administrative procedures as a recurring obstacle to translating adaptation plans into completed works. AMETSE similarly characterises local emergency response as reactive, noting that municipal officials are not always familiar with the practical meaning of weather-alert levels.

- Problem and wider system context. Phase 1 frames the problem as climate risk threatening four pillars of Murcia's economy: irrigated agriculture, coastal tourism, the Cartagena petrochemical hub and regional freight logistics. These hazards already affect quality of life, productivity and ecosystems (Calvin et al., 2023; IPCC, 2022): chronic drought threatens irrigated agriculture, heatwaves raise summer mortality and reduce labour productivity, and floods damage infrastructure, housing and crops. The region's vulnerability is compounded by structural trends identified in D1: soil erosion linked to advancing desertification removes up to 19 million tonnes of soil annually (Eekhout et al., 2021), and declining-rainfall projections point to further land abandonment (Andrade et al., 2021). Rapid, sometimes unregulated urbanisation has increased exposure: Murcia, Cartagena and Lorca show pronounced urban-heat-island effects (Gómez et al., 2023), and around 17% of homes in the region sit within flood-hazard zones (Cánovas-García and Vargas Molina, 2024). These vulnerabilities are shared with other Mediterranean regions and align Phase 2 with Spain's National Climate Change Adaptation Plan (MITECO, 2020). The Phase-2 interviews supply ground-level evidence that sharpens this picture rather than altering it. On agriculture, the Directorate-General for Food Industry and Agrarian Associations reports measured, not perceived, shifts: the apricot harvest has moved from late July to early/mid-June, rain-fed cereal output in the noroeste is down 50–60%, and the ovine herd in the same comarca has fallen 40–50%, with hail, frost and torrential rain now affecting crops outside their traditional season. On tourism, ITREM reports no measurable demand contraction to date (rural lodging occupancy up roughly 40% in 2025 and international visitor spend up around 14% in Q1) but flags structural exposure in coastal urbanizations built without flood cartography, such as Bahía Bella and Vallesor in Mazarrón. These accounts confirm that the problem framed in D1 is materialising unevenly across sectors: already visible and quantifiable in agriculture, still latent but spatially concentrated in tourism.
- Governance context. The governance inventory in Phase 1 remains current: the Regional Climate Change Adaptation Strategy (ERMACC, 2020, 15 action lines) is monitored by the Regional Observatory for Climate Change, a participatory body bringing together AEMET, the CHS basin authority, the Coastal Authority, businesses and civil society (AdapteCCa, 2025). Flood-risk governance rests on the 2007 Special Civil Protection Plan (INUNMUR), which maps flood-prone areas and coordinates emergency response with national civil protection

(CARM and DGPC, 2007). Phase-2 interviews add a practical, implementation-level layer to this inventory that was not directly evidenced in D1: DG IMAS cites a national Tribunal de Cuentas (Court of Auditors) finding that the Region of Murcia allocates negligible investment to the energy efficiency of public buildings, and several interviewees independently raised bureaucratic fragmentation and slow inter-administrative coordination as a constraint on turning ERMACC's action lines into completed measures. This evidence does not change the governance framework identified in Phase 1 but qualifies its practical reach.

- Relevant sectors. Phase 1's four sectors (irrigated agriculture, coastal tourism, petrochemicals, freight logistics) are confirmed and disaggregated by the Phase-2 interviews. Agriculture differentiates by sub-region: rain-fed cereal and extensive sheep farming in the noroeste (Caravaca, Moratalla) and dryland viticulture, almonds and olives on the altiplano (Yecla, Jumilla) face distinct exposure to drought and off-season frost/hail. Tourism is concentrated on the coast (La Manga, Mar Menor, Los Alcázares) for flood and erosion exposure, while diversifying inland toward gastronomic, wine and health tourism as a partial hedge. Two additional sectors emerge from the interviews that were not separately profiled in D1: social and health services, given IMAS facilities located in flood-prone zones (e.g. El Palmar, near the Guadalentín); and municipal energy management, given the exposure of public buildings and infrastructure to both heat and flood stress. Table 2-1 summarises the economic weight and expected climate impact of the four sectors profiled in D1, together with the two additional sectors identified in this phase.

Table 2-1 Economic weight and expected climate impact of the four sectors profiled in D1, together with the two additional sectors identified in Phase 2.

Sector	*Current weight*	*Principal climate stresses*	*Expected impact*
Irrigated agriculture & agri-food	4.6% of GVA; >11% employment (D1)	Chronic drought; heatwaves	Water-deficit yield loss, quality downgrades, higher cooling & fertigation costs
Coastal & cultural tourism	10.3% of GDP; highly seasonal (D1)	Heatwaves; coastal flooding; beach erosion	Thermal discomfort, loss of beach width, damage to second-home stock
Petro-chemical & energy hub	11.3% of GVA (oil refining, power) (D1)	Coastal surge; heat stress	Infrastructure downtime, safety hazards, supply-chain delays
Freight transport & logistics	12% of vehicle fleet are trucks/vans (D1)	River floods; heatwaves	Road closures, higher maintenance & fuel consumption
Social and health services (new in Phase 2)	Not quantified	Heatwaves; river floods (facilities in flood-prone zones)	Operational disruption to care facilities (e.g. IMAS sites near the Guadalentín); no systematic, proactive renewal of climate-control equipment (DG IMAS)
Municipal energy management (new in Phase 2)	Not quantified	Heatwaves; river floods	Exposure of public buildings and infrastructure to heat and flood stress; slow

Sector	Current weight	Principal climate stresses	Expected impact
			administrative procedures delay retrofit (Ayto. Murcia)

Note: weight figures for the first four sectors are reproduced from Phase 1 and were not re-estimated in Phase 2. The two sectors added in Phase 2 (social and health services; municipal energy management) were identified qualitatively through stakeholder interviews and have not been assigned a quantified economic weight in either phase.

- Outside influences. Phase 1 identifies several external initiatives that shape and resource the regional response: the EU Mission on Adaptation, whose methodological benchmarks and forthcoming "regional resilience contracts" the project intends to adopt; LIFE-ADAPTATE and Interreg NEXT MED, which contribute transferable tools for urban drainage, drought management and stakeholder engagement; the Segura River Basin Management Plan 2022–2027 (CHS, 2023), which the CRA is meant to inform; and the REPowerEU solar-irrigation programme. D1 treats this alignment as a source of complementary funding and best practice rather than a constraint, and Phase 2 has not identified evidence to revise that assessment; DG IMAS's reference to the national Tribunal de Cuentas (see Governance context, above) qualifies how an existing initiative is implemented rather than adding a new one. Two further outside influences were raised repeatedly in the Phase-2 interviews. First, the October 2024 Valencia DANA was cited by several interviewees (notably AMETSE) as a regional reference point: while it raised public and political awareness of flash-flood risk along the wider Mediterranean coast, interviewees were cautious about its direct applicability to Murcia, judging the region's hydrology and historical flood-control infrastructure (e.g. the 19th-century Paretón diversion works) to make an event of that exact scale unlikely, though not assessing residual risk as negligible. Second, the ongoing environmental crisis of the Mar Menor lagoon was repeatedly mentioned as a parallel process that has already produced a cross-disciplinary scientific advisory committee, cited by IMIDA as a working model that REGMURCIA's own stakeholder structures could draw on.
- Possible adaptation interventions. Phase 1 frames CLIMAAX-REGMURCIA's own output, rather than a single measure, as the project's main adaptation lever: framework strategies, technical guidelines and, where needed, proposals for regulatory amendments that feed directly into the Spatial Plan (PORM), municipal general plans and forthcoming climate-resilience bylaws, supported by a financing landscape spanning ERDF, LIFE, CAP eco-schemes, Next Generation EU and private green bonds. Interviewees proposed concrete, largely low-cost interventions that complement these strategic measures: restoring traditional irrigation channels (acequias) for passive urban cooling, reported by AMETSE to produce a localised 3–5°C effect; adapting school and working schedules to heat extremes; deploying denser, low-cost municipal weather-station networks; replacing climate-control equipment in public buildings on a planned rather than reactive basis (DG IMAS); strengthening and fully co-financing agricultural insurance and creating a dedicated dryland-farming support line (DG Industria Alimentaria y Asociacionismo Agrario, which notes regional co-financing of roughly €7M against an estimated need of €15–16M); and broadening multi-stakeholder scientific advisory committees on the Mar Menor model (IMIDA). Several interviewees also asked that CLIMAAX outputs be translated into directly actionable tools for non-specialist audiences, such as a citizen-facing flood-risk lookup by cadastral reference (IMIDA) and dissemination tailored to municipal councillors rather than

technical staff alone (AMETSE). None of these interventions has yet been adopted; they are recorded here as candidate inputs for the participatory work planned in Phase 3 (Section 2.6).

2.1.3 Participation and risk ownership

Stakeholder involvement process. Phase 2 stakeholder engagement builds on the two-tier model established in Phase 1 (D1, Section 2.1.3): a Tier 1 Risk-Ownership Committee of organisations with direct regulatory or operational responsibility for specific hazards, and a broader Tier 2 Consultation Panel engaged through the regional survey/Delphi process. For Phase 2, the project team selected nine organisations spanning both tiers for individual semi-structured interviews (approximately 30 minutes each, conducted by the UMU project team, recorded with consent and anonymized for transcription), prioritising institutions able to speak to recent, ground-level evidence of climate impacts and adaptation practice. Table 2-2 below maps these institutions to their role in the risk-ownership structure defined in Phase 1 and reports engagement status as of the date of this report.

Table 2-2 Interviewed institutions, their role in the risk-ownership structure defined in D1, and Phase 2 engagement status.

Institution	*Sector / role in risk ownership*	*Phase 2 engagement status*
IMIDA (Instituto Murciano de Investigación y Desarrollo Agrario y Medioambiental)	Agricultural research; Tier 1, all hazard workflows	Completed – 16/06/2026
DG IMAS (Instituto Murciano de Acción Social)	Social services / vulnerable groups; new in Phase 2	Completed – 18/06/2026
DG Industria Alimentaria y Asociacionismo Agrario	Agri-food policy; Tier 1, all hazard workflows	Completed – 18/06/2026
Agencia Local de la Energía y Cambio Climático (Ayuntamiento de Murcia)	Municipal energy & climate action; new in Phase 2	Completed – 18/06/2026
AMETSE (Asociación Murciana de Estudios sobre el Tiempo, el Clima y el Cambio Climático)	Meteorology / civil-society expert network; Tier 2 in D1 (Delphi), upgraded to interview in Phase 2	Completed – 19/06/2026
ITREM (Instituto de Turismo de la Región de Murcia)	Tourism; Tier 1, cross-sector	Completed – 19/06/2026
DG Ordenación del Territorio y Arquitectura	Spatial planning; Tier 1, exposure/land-use	Completed – 26/06/2026
FECOAM (Federación de Cooperativas Agrarias de la Región de Murcia)	Agricultural cooperatives; Tier 2	Completed – 26/06/2026
Ecologistas en Acción Región de Murcia	Environmental civil society; priority-group representation	Completed – shortly before submission

Risk ownership. Risk ownership in the Region of Murcia remains distributed across the institutional layers identified in Phase 1: river-basin and coastal hazard identification and mapping sit with the Confederación Hidrográfica del Segura and national meteorological services; emergency response and mitigation planning sit with CARM's Directorate-General for Civil Protection and municipal governments; land-use and building-code decisions that determine exposure sit with municipal planning departments and CARM's Directorate-General for Spatial Planning and Architecture; and sector-specific risk (agricultural, social-care, tourism) sits with the corresponding sectoral directorates-general. Phase 2 confirms this distribution and adds operational detail at facility and sector level, summarised below.

- Who is responsible. Hazard identification and mapping: Confederación Hidrográfica del Segura (river hazard) and AEMET (meteorological hazard monitoring). Risk assessment and mitigation planning: CARM's sectoral directorates-general (Civil Protection; Spatial Planning and Architecture; Industria Alimentaria y Asociacionismo Agrario; IMAS) and municipal governments, each within its statutory remit. Facility- and sector-level risk management: confirmed in the Phase 2 interviews to sit with the operating institution itself – for example DG IMAS for social-care facilities, and individual municipalities for local infrastructure – with limited cross-institutional coordination reported by several interviewees.
- Priority groups and their representatives. The Phase 2 interviews identify three priority groups with named institutional representatives: elderly and dependent residents of IMAS-operated social-care facilities located in flood-prone zones (represented by DG IMAS); smallholder rain-fed farmers and extensive livestock herders in the *Noroeste* and *Altiplano* comarcas, facing measured production declines (represented by *DG Industria Alimentaria y Asociacionismo Agrario* and FECOAM); and residents of coastal urbanizations built without flood cartography, such as Bahía Bella and Vallesor in Mazarrón (raised by ITREM). The *Ecologistas en Acción Región de Murcia* interview (completed shortly before this report's submission) adds environmental civil-society representation to these priority groups; its specific findings will be incorporated into this analysis in a subsequent update.
- Acceptable risk levels. Neither Phase 1 nor the Phase-2 interviews identify a formally adopted, quantitative risk-tolerance threshold for the Region of Murcia. This is consistent with Phase 1's limitation (ii) – incomplete vulnerability evidence – and remains an evidence gap. It is flagged here, rather than estimated, as a priority for a future phase.

2.1.4 Application of principles

Phase 2 applies the three CLIMAAX Framework principles below through the stakeholder engagement process described in Section 2.1.5 and through the data and methodological choices described in Section 2.3.

- Social justice, equity, inclusivity. The Phase 2 interview programme deliberately included institutions representing populations and sectors with limited capacity to self-advocate in regional climate planning: dependent and elderly residents of social-care facilities (DG IMAS), smallholder and extensive-livestock farmers in economically lagging interior comarcas (*DG Industria Alimentaria y Asociacionismo Agrario*, and FECOAM), and environmental civil society (*Ecologistas en Acción*; interview completed shortly before this report's submission, findings pending incorporation). This complements, rather than replaces, Phase 1's broader 145-organisation stakeholder map (D1, Table 2-2).
- Quality, rigour, transparency. The flood-risk re-analysis in Section 2.3 is built on a published, peer-reviewable methodology (Huizinga et al., 2017 depth-damage curves, implemented through the open-source DamageScanner library) and documents its data sources, assumptions and spatial resolution explicitly, so that the discrepancy between Phase 1 and Phase 2 damage estimates can be inspected and explained rather than presented as a

simple correction. Interview recordings were made with informed consent and transcripts were anonymized prior to analysis.

- Precautionary approach. Where Phase 2 evidence is incomplete or still pending – the one outstanding stakeholder interview, the absence of new quantitative work on the heatwave hazard, and the absence of a formally adopted regional risk-tolerance threshold – this deliverable states the gap explicitly rather than extrapolating from partial information.

2.1.5 Stakeholder engagement

Participation and risk ownership

Stakeholder participation and risk ownership are central components of the Phase 2 Climate Risk Assessment developed within the REGMURCIA CLIMAAX project. Climate-related risks in the Region of Murcia affect multiple sectors, territories, administrative levels and population groups, while responsibility for their prevention, management and adaptation is distributed across a wide range of institutions.

The participatory approach implemented in Phase 2 is coherent with the objectives established in Phase 1. That first deliverable defined the need to move from preliminary hazard screening towards a more detailed and participatory assessment able to support higher-resolution analysis, risk prioritisation and the future design of adaptation measures. It also established the importance of linking the scientific assessment with regional decision-making, sectoral planning and stakeholder ownership.

During Phase 2, this structure was operationalised through a more detailed participatory process. Stakeholder involvement was not conceived as a single consultation event, but as a sequence of complementary activities aimed at improving the quality, relevance and usability of the Climate Risk Assessment. These activities included an expert review of the consultation instruments based on a Delphi-informed design, a structured stakeholder survey, semi-structured interviews and the subsequent triangulation of stakeholder evidence with the regionalized risk-analysis results.

The main stakeholder groups considered in the process include regional public administrations, municipal authorities, water-management organisations, civil-protection and emergency-management services, public-health and social-service institutions, agricultural and agri-food representatives, tourism-sector actors, transport and logistics operators, energy and industrial stakeholders, critical-infrastructure managers, environmental organisations, academic and research institutions, professional associations, business and sectoral organisations, civil-society entities and representatives of exposed territories or vulnerable population groups.

Risk ownership in the Region of Murcia is shared across several governance levels and institutional domains. No single organisation has exclusive responsibility for all dimensions of climate risk. Responsibilities vary according to the hazard considered, the exposed system, the population affected, and the type of action required.

The regional administration has a central role in strategic climate policy, territorial planning, environmental management, public health, agriculture, infrastructure, civil protection and the coordination of adaptation measures. Municipal governments are responsible for many locally relevant functions, including urban planning, public-space management, maintenance of local infrastructure, emergency preparedness, social services, public communication and the practical implementation of adaptation measures at neighbourhood and municipal level. National and basin-level institutions retain key responsibilities for meteorological monitoring, water-resource management, flood-risk planning, coastal management, national infrastructure and regulatory frameworks.

Private operators and sectoral organisations also hold relevant responsibilities where climate risks affect energy, transport, industrial facilities, tourism, agriculture, insurance, supply chains and other economic activities. Research institutions and universities support risk ownership by providing scientific evidence, methodological development, data analysis, training and independent technical interpretation. Civil-society organisations, professional associations and environmental groups contribute territorial knowledge, social perspectives and experience on impacts, preparedness and the acceptability of adaptation measures.

This distribution of responsibilities makes coordination a critical aspect of climate-risk governance. Climate hazards in the Region of Murcia may generate cascading and cross-sectoral effects. Drought may affect water availability, agriculture, ecosystems, energy demand, employment and food-production systems. Flooding may disrupt housing, transport, emergency access, public services, industrial activity and critical infrastructure. Heatwaves may affect health, labour productivity, energy consumption, tourism and social-service demand. Coastal flooding may affect tourism, residential areas, transport corridors, ports, coastal ecosystems and strategic industrial facilities.

The Phase 2 participatory process therefore seeks to clarify not only which stakeholders are affected by climate risks, but also who is responsible for identifying, monitoring, preventing, managing, financing and responding to them. It also seeks to identify which actors control relevant information, which institutions have the capacity to implement adaptation measures and which groups must be consulted because they are particularly exposed or vulnerable:

- legal and administrative responsibility;
- technical and operational capacity;
- access to data and information;
- financial resources;
- territorial proximity;
- responsibility for emergency response and recovery;
- representation of exposed or vulnerable groups;
- ability to influence planning, investment, regulation and implementation.

The process also recognises that formal responsibility does not always correspond to effective adaptive capacity. Some institutions may have legal mandates but limited financial, technical, human or informational resources. Conversely, some actors may possess relevant local knowledge or implementation capacity despite having limited formal authority. This distinction is essential for assessing resilience capacity and for identifying realistic adaptation measures.

The stakeholder matrix prepared during Phase 1 was used as the starting point for Phase 2. It classified stakeholders according to the preferred mode of engagement and the climate-risk workflow to which they were most closely connected. The matrix included actors initially assigned to interviews, Delphi consultation and survey dissemination. The initial plan considered 79 different entities for the stakeholder survey, 34 expert consultations for the Delphi-informed review and 46 semi-structured interviews. These figures were used as the operational reference for Phase 2 stakeholder engagement (Figure 2-1 and Table 2-3).

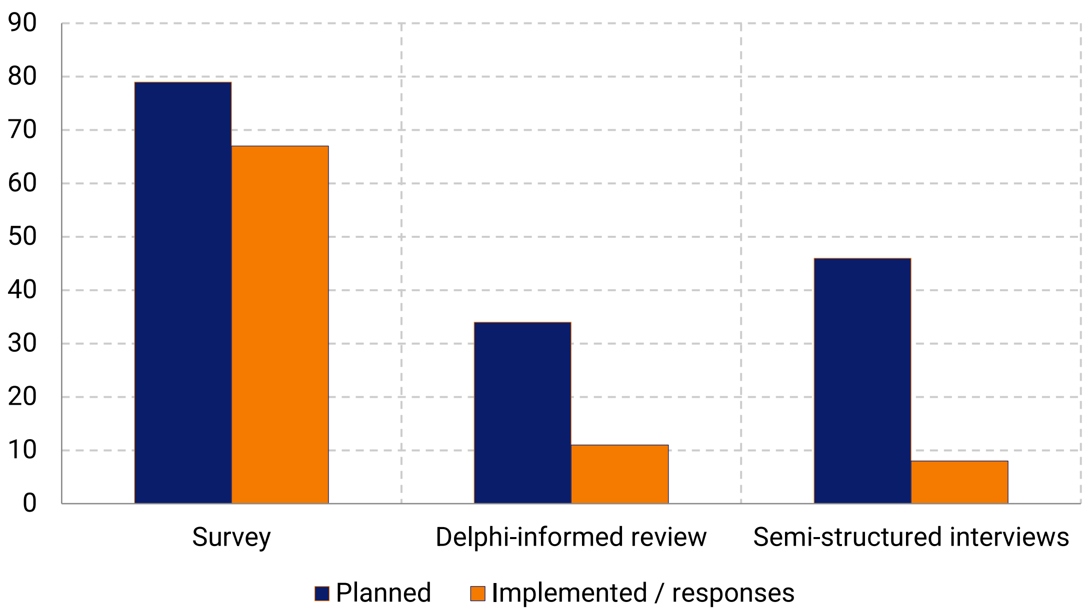

Figure 2-1 Initial stakeholder engagement structure derived from the Phase 1 stakeholder matrix. Source: REGMURCIA CLIMAAX stakeholder matrix.

Table 2-3 Initial stakeholder engagement structure derived from Phase 1.

Engagement mode	*Initial stakeholder units*	*Main purpose in Phase 2*	*Expected contribution*
Interview	46 interviews planned	In-depth qualitative consultation	Contextual interpretation of risks, institutional preparedness, governance barriers, sectoral impacts and adaptation priorities.
Delphi-informed review	34 expert consultations planned	Expert review of consultation instruments	Review and improvement of the original interview guide and survey before wider dissemination.
Survey	79 different entities planned	Wider structured consultation	Comparable information on perceptions, adaptation measures, preparedness, information use and organisational capacity.

The final engagement process combined planned participation with adaptive changes introduced during implementation. In practice, the Delphi-informed review helped redesign the consultation instruments; the survey generated 67 response records, although these do not correspond to 67 different entities because some organisations or institutional areas may be represented by more than one respondent; and 8 semi-structured interviews were conducted or processed with selected actors representing institutional, technical, sectoral and territorial perspectives. Although the level of participation was lower than initially expected in some instruments, the survey return is considered strong in relation to the initial target of 79 entities, with 67 response records collected. Even considering that these responses are not equivalent to 67 unique entities, the dataset is methodologically acceptable for the interpretative objectives of Phase 2 because it covers a broad variety of responsibilities, institutional positions, territorial perspectives and climate-governance concerns. The smaller number of completed interviews should be interpreted as a targeted qualitative sample rather than as the full implementation of the initial interview target.

Stakeholder engagement methodology and workflow

The stakeholder engagement process in Phase 2 was organised as a sequential and adaptive methodology. Its purpose was to ensure that the participatory instruments were adequate before implementation, that a sufficiently broad group of stakeholders could provide structured information and that key actors could contribute more detailed qualitative evidence through interviews.

The methodology was developed in five main stages: stakeholder identification and classification; Delphi-informed expert review of the original consultation instruments; revision and closure of the final survey and interview guide; implementation of the quantitative survey and semi-structured interviews; and future triangulation of stakeholder evidence with the regionalized risk-analysis results (Table 2-4).

Table 2-4 Methodological workflow for stakeholder consultation in Phase 2.

Stage	*Instrument or action*	*Main objective*	*Output*
1. Stakeholder mapping	Phase 1 stakeholder matrix	Identify relevant actors and assign them to engagement modes.	Initial engagement list by stakeholder type, hazard/workflow and method.
2. Pre-Delphi materials	Original survey and draft interview approach	Prepare consultation instruments for expert review.	Draft questionnaire and interview structure.
3. First Delphi-informed round	Workshop feedback and email consultation	Identify problems in length, focus, wording and relevance.	Expert feedback and technical corrections.
4. Revision of instruments	Internal methodological revision	Incorporate feedback and adapt tools to regional stakeholders.	Final stakeholder survey and semi-structured interview guide.
5. Second Delphi-informed round	Resubmission of revised instruments	Seek further expert validation or additional comments.	No additional responses received; instruments closed.
6. Survey implementation	Final Google Forms questionnaire	Collect comparable stakeholder information.	67 survey response records, not necessarily 67 unique entities.
7. Semi-structured interviews	Final interview guide	Obtain deeper qualitative evidence.	9 conducted or processed interviews.
8. Integration and validation	Triangulation with modelled results	Compare stakeholder evidence with technical risk analysis.	Integrated in Sections 2.4.7 and 2.4.8; further validation planned in Phase 3.

The process was designed to combine comparability and depth. The survey allowed the project to collect structured information from a wider stakeholder base, while the interviews provided the flexibility needed to explore specific institutional, territorial and sectoral issues in more detail. The Delphi-informed review served as an intermediate methodological quality-control step, helping ensure that the final instruments were clearer, shorter and better adapted to the Region of Murcia.

The participatory process was also designed to address several dimensions required by the CLIMAAX Key Risk Assessment framework. These include perceived severity, urgency, adaptive and response capacity, information needs, existing measures, barriers to implementation and priorities for adaptation.

The stakeholder engagement process was not treated as a statistically representative survey of the whole regional population. Instead, it was conceived as a structured consultation of relevant stakeholders, experts and institutions. Its value lies in capturing informed perspectives from actors with professional, institutional, sectoral or territorial knowledge of climate-related risks. The evidence obtained through this process will be used carefully and in combination with other sources. Stakeholder perception will not automatically replace quantitative risk outputs. Instead, it will be used to contextualize, interpret and, where necessary, question or qualify model-based results.

Delphi-informed expert review of consultation instruments

Before launching the stakeholder survey and the semi-structured interviews, the REGMURCIA CLIMAAX team carried out an expert consultation based on a two-round Delphi-informed approach. At this stage, the Delphi process was not intended to validate the final climate-risk modelling results. Its function was methodological: to review and refine the two main instruments that would later be used with stakeholders, namely the semi-structured interview guide and the quantitative stakeholder survey.

The purpose was to assess whether the instruments were understandable, relevant, balanced, proportionate in length and suitable for the different types of stakeholders expected to participate in Phase 2. This was particularly important because the consultation had to include public administrations, technical services, research institutions, sectoral bodies, professional organisations, environmental associations and local authorities, not only private companies or business organisations.

The original questionnaire used before the Delphi-informed review was based on organisational adaptation practices. It included 35 questions on climate-change beliefs, stakeholder pressure, environmental management, adaptation strategies, monitoring and evaluation, capacity building, environmental performance, organisational resilience and demographic information. Although methodologically structured, the first version was strongly oriented towards organisational and business practices and did not yet include a sufficiently developed block on concrete adaptation measures for the hazards analysed in REGMURCIA CLIMAAX. The original pre-Delphi questionnaire is documented in Annex-REGMURCIA_CLIMAAX-Original-Survey.

Preliminary presentation during the COAST CRAFT study visit

The Delphi-informed process was preceded by a dissemination and engagement activity held in the context of the COAST CRAFT Interreg Europe study visit organised in the Region of Murcia on 17 and 18 March 2026. The meeting brought together political and technical representatives from the Region of Murcia, European project partners and other stakeholders. Participating international partners represented institutions from Italy, Belgium, Albania, the Netherlands, Bulgaria and Lithuania.

During the session dedicated to stakeholder presentations, the REGMURCIA CLIMAAX project was introduced to the participants. The presentation explained the objectives and scope of REGMURCIA CLIMAAX, the role of stakeholder participation within the Climate Risk Assessment, the purpose of the semi-structured interviews and quantitative questionnaire, and the type of expert review requested before their wider application.

This event served both as a dissemination action and as an initial opportunity to present the consultation instruments to a diverse group of institutional and technical actors. The international and multidisciplinary composition of the meeting provided access to experience from different administrative and territorial contexts, although not all participants had the same degree of familiarity with the specific institutional and climate-risk conditions of the Region of Murcia.

First Delphi-informed round: feedback on the original instruments

After the preliminary presentation, the original consultation materials were circulated among the selected experts by means of a standardised email. The materials included the original survey and the draft structure of the semi-structured interview process. Experts were asked to review the relevance of the thematic blocks, the clarity of the questions, the appropriateness of the language, the balance between institutional, territorial, social and economic issues, the expected completion time and the suitability of the questions for different stakeholder profiles.

The first stage of feedback produced several relevant observations. During the workshop, various interventions highlighted that both the interview guide and the survey were too long. Participants indicated that the expected time required to complete them could discourage participation, particularly among senior public officials, technical staff with limited availability and stakeholders whose participation depended on voluntary engagement.

Several comments also indicated that the initial materials were too strongly focused on companies and organisational business practices. Although these dimensions were relevant, they were not sufficiently adapted to the responsibilities, knowledge and decision-making context of public administrations and technical bodies. The initial questionnaire also did not pay sufficient attention to concrete adaptation measures for the main hazards addressed in the project, such as river and pluvial flooding, coastal flooding and sea-level rise, heatwaves, drought and water scarcity.

- excessive length of the original instruments;
- excessive emphasis on business and company-centred adaptation practices;
- insufficient attention to public-administration responsibilities;
- limited coverage of institutional preparedness and governance;
- insufficient focus on coordination between regional and local administrations;
- limited attention to public services and emergency management;
- insufficient development of questions on political commitment and implementation barriers;
- absence of a sufficiently explicit block on concrete adaptation measures by hazard;
- need to simplify language and reduce technical or academic wording.

The email consultation generated additional feedback. Of all experts consulted, seven provided similar substantive feedback. Their comments reinforced the concerns raised during the workshop, especially the need to shorten the instruments, simplify their wording and shift the focus towards public administration, governance, preparedness, coordination and adaptation policy. A further four experts provided mainly technical corrections to the questionnaire and interview guide. These corrections addressed wording, formatting, question order, response options, duplication and clarity. The remaining experts did not provide feedback (Figure 2-2).

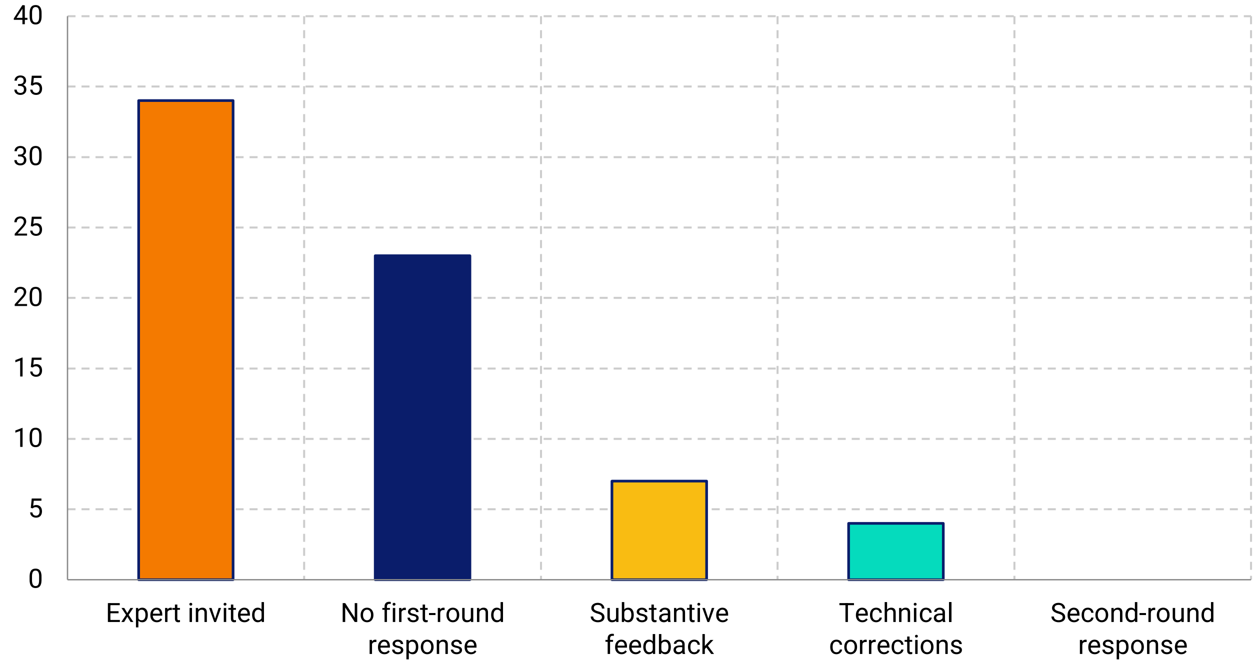

Figure 2-2 Delphi-informed expert review: first- and second-round response pattern.

Although participation was lower than expected, the responses received were sufficiently consistent to identify a clear set of methodological improvements. The low response rate was therefore treated not only as a limitation, but also as evidence that the original consultation materials demanded excessive time and were not optimally adapted to the needs and responsibilities of all intended participants.

Revision from the pre-Delphi questionnaire to the final survey

The Delphi-informed review led to a substantial transformation of the original questionnaire. The pre-Delphi survey was not simply shortened; it was reoriented from a broad organisational-adaptation questionnaire towards a regional climate-risk and adaptation questionnaire adapted to the governance context of the Region of Murcia (Table 2-5).

Table 2-5 Main changes from the pre-Delphi survey to the final stakeholder survey.

Dimension	*Original pre-Delphi survey*	*Final stakeholder survey*
General orientation	Organisational adaptation practices, with strong emphasis on companies and management structures.	Climate-risk perception, adaptation measures, preparedness and information use in the Region of Murcia.
Length	35 questions, including several long matrices and organisational constructs.	31 questions, with simplified wording and more direct thematic structure.

Target audience	More suitable for companies and organisations with formal management structures.	Adapted to public administrations, local authorities, professional bodies, associations, research centres and sectoral entities.
Hazard-specific adaptation	Limited development of concrete adaptation measures by hazard.	Specific blocks on river/pluvial flooding, coastal flooding and sea-level rise, heatwaves, drought and water scarcity.
Governance and public administration	Indirectly addressed through stakeholder pressure and organisational variables.	Strengthened through questions on budgets, training, monitoring, evaluation, information use, resilience and institutional capacity.
Language and usability	More academic and business-oriented terminology.	Simpler language, shorter explanations and response options adapted to non-academic participants.
Reproducibility	Documented as original pre-Delphi material in Annex.	Documented in Spanish and English as final survey in Annex.

The principal changes included reducing the overall length of the survey and interview guide; removing or merging duplicated questions; simplifying language and reducing unnecessary technical terminology; reducing the relative weight of business-oriented questions; strengthening the focus on public administrations and institutional responsibilities; incorporating clearer questions on preparedness, anticipation and response capacity; improving the treatment of coordination between administrations and sectors; expanding the sections on vulnerable groups, exposed territories and public services; improving the questions on current and expected climate impacts; introducing more direct questions on adaptation priorities and feasible measures; and improving the organisation and sequence of the thematic blocks.

The revised survey was transformed into a more regionally relevant questionnaire focused on climate-risk perception, adaptation measures, organisational preparedness, information use, resilience and respondent characteristics. The revised interview guide was designed as a conversational instrument for interviews of approximately 30 minutes. It was structured around perception of climate change, current and expected impacts, preparedness, governance, barriers, adaptation measures and the usefulness of REGMURCIA CLIMAAX results.

Second Delphi-informed round and closure

The revised instruments were returned to the expert panel by email as the second round of the Delphi-informed review. The purpose of the second round was to allow experts to review the changes introduced after the first round, assess whether their comments had been adequately incorporated, identify any remaining methodological problems and express agreement, disagreement or further recommendations.

No responses were received during the second round. Consequently, it was not possible to assess the degree of convergence, stability of judgement or consensus among the expert panel. For this reason, the process cannot be described as a fully completed Delphi exercise. It is more accurately defined as an expert consultation informed by a two-round Delphi design.

Nevertheless, the first round generated clear and actionable feedback and resulted in a substantial improvement of the consultation instruments. In the absence of additional comments in the second round, the revised instruments were closed and adopted as the final survey and final semi-structured interview guide for Phase 2.

The experience showed that written expert consultations without personalized follow-up may be insufficient to maintain participation across successive rounds. It also demonstrated the need to define a smaller and more specifically committed expert panel, agree on participation before launching the first round, establish clear deadlines and reminders, provide concise review templates and complement email consultation with direct interviews or dedicated review meetings. These lessons informed the subsequent stakeholder engagement strategy. Rather than relying exclusively on repeated written expert consultation, the project proceeded with a combination of a shortened quantitative survey and semi-structured interviews with directly relevant regional stakeholders.

Quantitative stakeholder survey: methodology and participation

The quantitative stakeholder survey was designed to collect comparable information from a broader group of institutions, organisations, professional bodies, associations and territorial actors in the Region of Murcia. The final questionnaire was implemented after the Delphi-informed review and incorporated the main changes resulting from expert feedback.

Compared with the original pre-Delphi questionnaire, the final survey was shorter, more accessible and more directly connected to climate-risk assessment and adaptation in the Region of Murcia. It included 31 questions and was prepared in Spanish. The final survey was implemented in Spanish. However, for greater reproducibility, Annex-REGMURCIA_CLIMAAX-Final-Survey_Bilingual presents the final survey both in its original language and translated into English. The operational version was implemented through Google Forms.

The final survey was organised into four thematic blocks: perception of climate change and its impacts; adaptation measures for different climate risks; adaptation capacity, monitoring, evaluation and information use; and general information about the respondent and/or their organisation, entity or activity (Table 2-6).

Table 2-6 Thematic structure of the final stakeholder survey.

Survey block	*Questions*	*Purpose*
Perception of climate change and impacts	Q1-Q5	Assess belief in climate change, perceived causes, expected impacts and level of concern.
Adaptation measures for climate risks	Q6-Q10	Evaluate the perceived importance of specific adaptation measures for river/pluvial flooding, coastal flooding, heatwaves, drought and water scarcity.
Adaptation capacity and information use	Q11-Q18	Assess budget, training, monitoring, evaluation, information use, resilience and strategies to address climate risks.
Respondent and organisation profile	Q19-Q31	Characterise the respondent, organisation, sector, territorial context and activity.

Objectives of the survey

The survey had several specific objectives: to assess whether stakeholders consider climate change to be a current and relevant reality for the Region of Murcia; to identify the expected severity of climate impacts over the next decades; to measure concern regarding impacts on individuals, local communities, the country, the global population and ecosystems; to assess the perceived importance of adaptation measures for river flooding, intense rainfall, coastal flooding, sea-level rise, heatwaves, drought and water scarcity; to identify other adaptation measures proposed by stakeholders; to evaluate whether organisations have specific budgets and training related to climate adaptation; to assess the frequency with which organisations monitor and evaluate adaptation actions; to identify the types of climate information and maps used by organisations; to assess perceived organisational resilience and response capacity; and to characterise the institutional, territorial and sectoral profile of respondents.

The survey therefore provides a structured basis for analysing stakeholder perceptions of climate risk, adaptation priorities and organisational preparedness. It will also support the later interpretation of severity, urgency and resilience capacity in the Key Risk Assessment step.

Survey dissemination and participation

The survey was disseminated among stakeholders identified during Phase 1 and through additional contacts generated during Phase 2. The dissemination strategy sought to reach regional and local administrations, universities and research centres, technical bodies, environmental organisations, professional associations, health and social-service entities, agricultural representatives, emergency services and other organisations with relevant knowledge of climate risks and adaptation in the Region of Murcia.

A total of 67 response records were collected. The Phase 1 plan had envisaged distributing the survey to 79 different entities. The number of responses obtained is therefore more than acceptable for the objectives of this consultation, although the response records should not be interpreted as 67 different entities because some organisations or institutional areas may be represented by more than one respondent. However, the responses obtained are considered sufficient to support the qualitative and interpretative objectives of the stakeholder consultation because they represent a broad range of responsibilities, institutional roles, professional profiles and climate-related concerns within the regional governance context.

The survey responses include regional administration bodies, municipal administrations, universities and research/technical entities, public-health and social-service actors, professional associations, environmental and meteorological associations, agricultural representatives, emergency services and civil-society organisations. The strong presence of regional and local public administrations is especially relevant for this phase, given that many adaptation decisions depend on planning, coordination, regulation, technical capacity and implementation at different administrative levels (Figure 2-3 and Table 2-7).

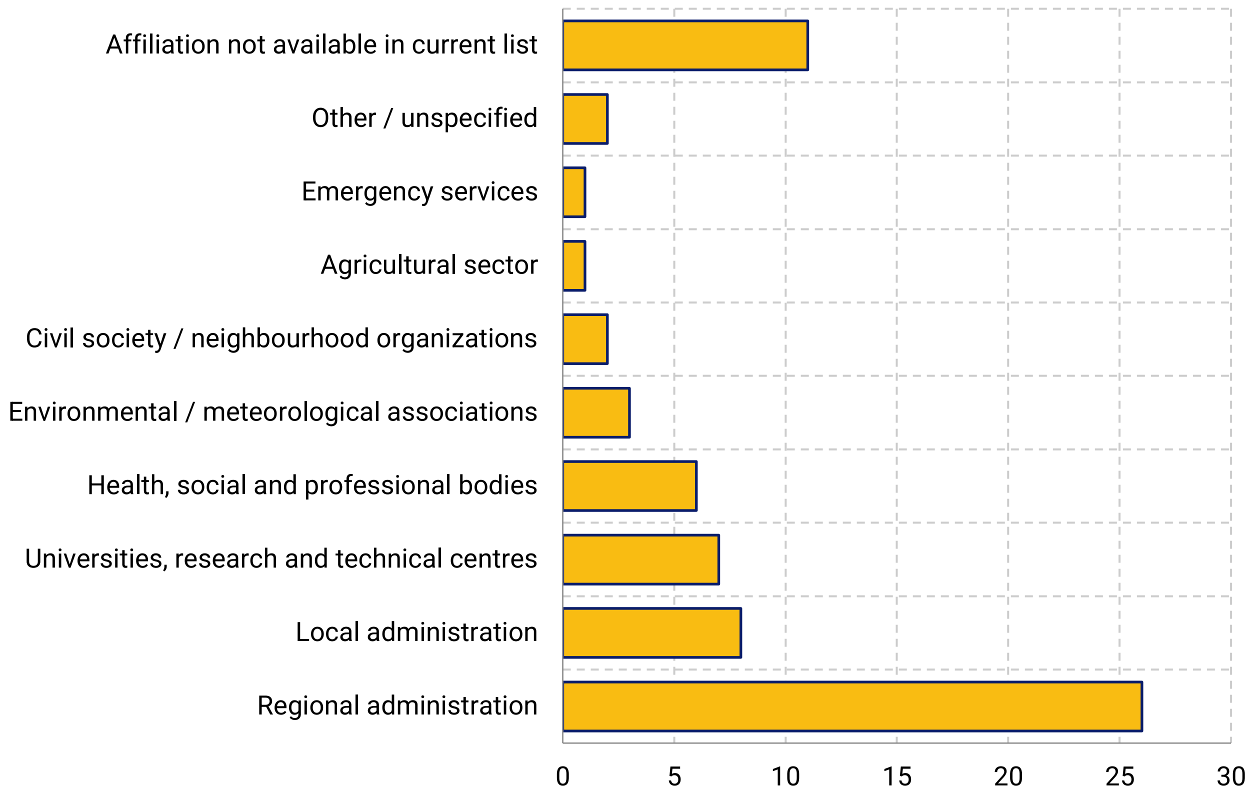

Figure 2-3 Preliminary classification of survey participation by stakeholder group. Note: 67 response records were collected; the working affiliation list currently contains 56 identifiable affiliation entries, while 11 response records are shown as requiring final affiliation cleaning before the results section.

Table 2-7 Analytical classification of survey respondents by stakeholder group.

General stakeholder group	*Examples of respondents included*	*Analytical relevance*
Regional administration	CARM, Dirección General de Patrimonio Natural y Acción Climática, Dirección General de Medio Natural, Consejería de Medio Ambiente, Subdirección General de Infraestructuras, Dirección General de Industria, Energía y Minas, environmental agents.	Strategic planning, regulation, environmental management, infrastructure, climate policy and implementation capacity.
Local administration	Municipalities such as Librilla, Cieza, Alcantarilla, Cartagena, Los Alcázares, Murcia and Lorquí.	Local exposure, urban planning, municipal services, emergency preparedness and implementation barriers.
Universities, research and technical centres	UPCT, Universidad de Murcia, CETENMA.	Technical knowledge, climate-risk interpretation, data and methodological assessment.
Health, social and professional bodies	Servicio Murciano de Salud, public health, nursing, social work, veterinary, agricultural engineering and geography professional bodies.	Vulnerable groups, public health, social impacts, professional practice and sectoral adaptation.

Environmental and meteorological associations	AMETSE, MeteoNoroeste, ANIDA and related associations.	Local observation, environmental impacts, risk perception and territorial knowledge.
Agricultural sector	COAG Murcia and related actors.	Drought, water scarcity, agricultural vulnerability and adaptation measures.
Emergency services	Regional fire and rescue consortium and related operational bodies.	Emergency response, preparedness, wildfire/flood response and operational capacity.
Civil society and other actors	Neighbourhood associations, other associations and unspecified entries.	Social perception, local concerns, public acceptability and additional territorial knowledge.

Semi-structured interviews: methodology and sample

Semi-structured interviews were used to obtain deeper qualitative information from selected stakeholders. While the survey provides comparable responses across a broader group, interviews allow participants to explain their perceptions, experiences, institutional constraints and adaptation priorities in greater detail.

The interview guide was developed after the Delphi-informed review and reflects the main methodological lessons from that process. It was designed as a flexible conversational instrument rather than a closed questionnaire. Its purpose was to ensure that all relevant topics were covered while allowing the interviewer to adapt the conversation to the profile, responsibilities and expertise of each participant. The interview guide is included as Annex-REGMURCIA_CLIMAAX-Semi-Structured-Interview-Guide in Spanish and English for reproducibility.

Objectives of the interviews

The interviews had the following objectives: to explore stakeholders' perception of climate change in the Region of Murcia; identify the climate risks considered most relevant by each institution or sector; document current impacts already observed by stakeholders; identify expected future impacts and risks that may become more serious over time; detect exposed territories, sectors, infrastructure, ecosystems and population groups; assess perceived preparedness, anticipation and response capacity; identify weaknesses in data, planning, coordination, financing, technical resources or political leadership; examine governance barriers and conflicts between economic, territorial, environmental and social objectives; collect proposals for adaptation measures and strategies; and identify how REGMURCIA CLIMAAX outputs could be useful for stakeholders.

Interview design

The interview guide was structured into eight thematic blocks: introduction of the project and framing of the conversation; general perception of climate change in the Region of Murcia; main climate risks and current impacts; expected impacts and future evolution of risk; preparedness, anticipation and response capacity; political engagement, governance and barriers; priorities, strategies and adaptation measures; and usefulness of the CLIMAAX project and future collaboration.

The guide also included examples of adaptation measures for drought and agriculture, fluvial flooding, coastal flooding and heatwaves. These examples were not intended to lead responses, but to help open the conversation if participants did not spontaneously mention specific measures.

The indicative duration of each interview was approximately 30 minutes. Before beginning the interview, participants were informed of the purpose of the conversation, the voluntary nature of participation and the intended use of the information. Permission to record the interview was requested when appropriate, explaining that recordings would be used only to support transcription and that the anonymity of participants would be preserved in the reporting of results unless explicit authorization was provided.

Interviewed stakeholders

Nine interviews were conducted or formally processed during this stage. Although this number is lower than the initial target established in the Phase 1 engagement plan, the final interview sample provides a relevant and methodologically useful qualitative basis for the Phase 2 stakeholder assessment (Table 2-8).

The value of the interview process does not depend only on the number of interviews completed, but also on the institutional relevance, sectoral diversity and analytical depth of the stakeholders involved. Semi-structured interviews are resource-intensive instruments that require direct contact, scheduling, preparation, implementation, transcription, synthesis and thematic interpretation. For this reason, the qualitative contribution of each interview is substantially higher than that of a short standardised response.

The interviewed or contacted entities cover several key dimensions of climate-risk governance in the Region of Murcia: municipal climate action, meteorological observation, social vulnerability, agri-food policy, territorial planning, agricultural cooperatives, agricultural and environmental research, and tourism. This combination provides information from public administrations, technical and scientific bodies, sectoral organisations and entities linked to exposed or vulnerable systems.

The interview sample therefore supports the interpretation and contextual validation of the stakeholder consultation results, despite not reaching the initially planned number. It captures a wide range of responsibilities and concerns related to the main hazards addressed by REGMURCIA CLIMAAX, including drought and water scarcity, heatwaves, river and coastal flooding, territorial exposure, vulnerable populations, agricultural impacts, tourism vulnerability, preparedness, governance barriers and adaptation priorities.

The interviews should consequently be interpreted as a targeted qualitative consultation rather than a statistically representative sample. Their function is to provide depth, explanation and institutional context, complementing the broader quantitative survey and the technical risk assessment. In this sense, the diversity and relevance of the interviewed stakeholders validate their use as a robust qualitative layer within the overall triangulation process of Phase 2.

Table 2-8 Semi-structured interviews conducted or processed in Phase 2.

No.	*Entity / stakeholder*	*General stakeholder group*	*Main expected contribution*
1	Agencia Local de la Energía y Cambio Climático, Ayuntamiento de Murcia	Local administration / climate and energy	Urban adaptation, municipal climate action, heat, energy and local governance.
2	AMETSE, Asociación Meteorológica del Sureste	Meteorological / civil-society technical association	Local climate observation, extreme events, rainfall, heatwaves and public perception.
3	Dirección General / IMAS	Social services / vulnerable groups	Social vulnerability, exposed populations, preparedness and social response capacity.
4	Dirección General de Industria Alimentaria y Asociacionismo Agrario	Regional administration / agri-food sector	Drought, agriculture, agri-food systems and sectoral adaptation.
5	Dirección General de Ordenación del Territorio y Arquitectura	Regional administration / territorial planning	Land-use planning, exposure, flood/coastal risk and adaptation in planning instruments.
6	FECOAM	Agricultural cooperative sector	Agricultural impacts, water scarcity, drought adaptation and sectoral feasibility.
7	IMIDA	Research / agricultural and environmental development	Scientific and technical knowledge on agriculture, water, crops and adaptation.
8	ITREM	Tourism sector / regional public body	Tourism vulnerability, coastal areas, heat, seasonality and adaptation of tourist destinations.
9	Ecologistas en Acción Región de Murcia	Environmental civil society	Environmental impacts, territorial conflicts, ecosystem vulnerability, Mar Menor, coastal and land-use concerns. Completed shortly before submission; not incorporated into the present analysis.

Integration of stakeholder evidence and future validation

The stakeholder evidence collected through the Delphi-informed review, the quantitative survey and the semi-structured interviews will be integrated into the Phase 2 Climate Risk Assessment in several ways. First, the Delphi-informed review improved the quality and relevance of the instruments used to collect stakeholder information. Although it did not result in a formal expert consensus, it provided actionable methodological feedback and led to a more suitable survey and interview guide.

Second, the survey provides a structured overview of how different stakeholders perceive climate change, climate impacts, adaptation measures, preparedness, information use and organisational resilience. Third, the interviews provide qualitative depth and allow the project to understand why certain risks, barriers or measures are considered important by specific institutions or sectors. Fourth, the stakeholder evidence is compared with the regionalized modelling results in Sections 2.4.7 and 2.4.8. This comparison supports a multi-source interpretation of risk, identifying points of convergence between modelled outputs and stakeholder perception, divergences between quantitative results and local or institutional experience, governance or capacity factors that may increase or reduce actual risk, and implications for severity, urgency, resilience capacity and risk prioritisation.

Further validation will be developed during Phase 3 through sectoral technical working tables and participatory workshops. At this stage, stakeholder engagement should therefore be understood as both a methodological and interpretative layer of the Climate Risk Assessment and as the basis for translating the integrated KRA into feasible adaptation measures.

Quantitative stakeholder survey: results

This section presents the statistical analysis of the 67 response records collected through the final stakeholder survey. The analysis is descriptive and inferential in an interpretative sense: it identifies patterns, internal contrasts and likely implications for the REGMURCIA CLIMAAX Climate Risk Assessment, but it does not treat the survey as a statistically representative sample of all institutions, organisations or residents in the Region of Murcia.

For confidentiality and statistical secrecy, results are reported only in aggregate form. Individual entities are not identified in the analysis, and open-text answers are synthesized thematically rather than reproduced as attributable statements. Where stakeholder groups contain very few responses, results are not interpreted separately; they are used only as part of broader aggregated categories.

Respondent profile and institutional coverage

The response profile is strongly oriented towards public and technical stakeholders, which is consistent with the governance-oriented objectives of Phase 2. Regional administration represents the largest category of response records, followed by universities and technical centres, local administrations, and health, social and professional bodies. This composition is important for the interpretation of the results: the survey mainly captures the views of actors involved in planning, management, monitoring, regulation, professional practice and public-service provision, rather than general public opinion (Table 2-6).

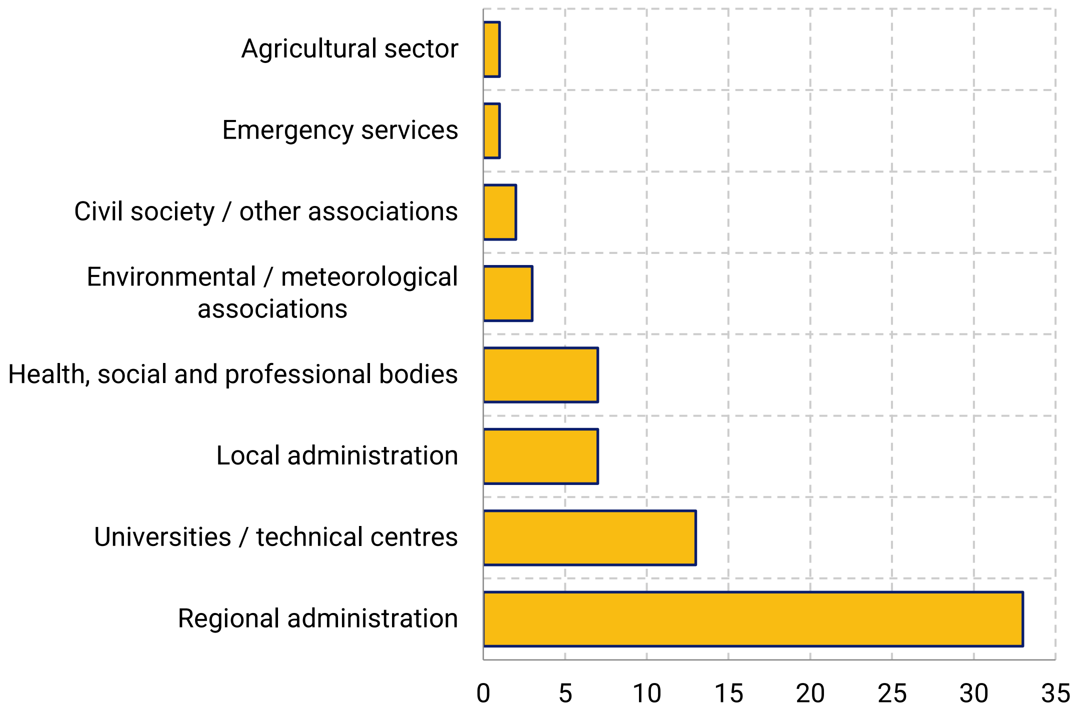

Figure 2-4 Survey participation by stakeholder group. Source: REGMURCIA CLIMAAX stakeholder survey, n=67 response records.

The distribution of responses confirms that the survey has a strong institutional basis. This is an advantage for the CLIMAAX Key Risk Assessment because the questions on preparedness, monitoring, data use and adaptation measures require knowledge of organisational capacities and public-policy implementation. At the same time, the concentration of responses in regional administration means that results should be interpreted as a stakeholder and expert-informed consultation, not as a balanced social survey.

Perception of climate change and its causes

The survey shows a very high level of recognition of climate change among stakeholders. Of the 67 response records, 63 (94%) state that climate change is a reality, three select “do not know”, and one selects “no”. This indicates that the participatory sample is characterised by a broad baseline acceptance of climate change as a relevant issue for the Region of Murcia (Figure 2-5).

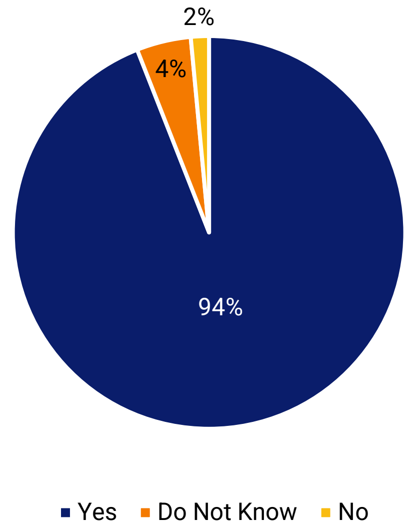

Figure 2-5 Perception of climate change as a reality. Source: REGMURCIA CLIMAAX stakeholder survey, n=67.

The perceived role of human activities is also high. The mean score on the 1-7 scale is 6.0, with 51 responses located at values 6 or 7. This suggests that most respondents do not interpret observed climate risks as purely natural variability, but as processes strongly associated with human-driven climate change. This has implications for adaptation governance: if climate risks are understood as structural and human-influenced, there is a stronger basis for preventive planning and policy intervention rather than purely reactive emergency management (Figure 2-6).

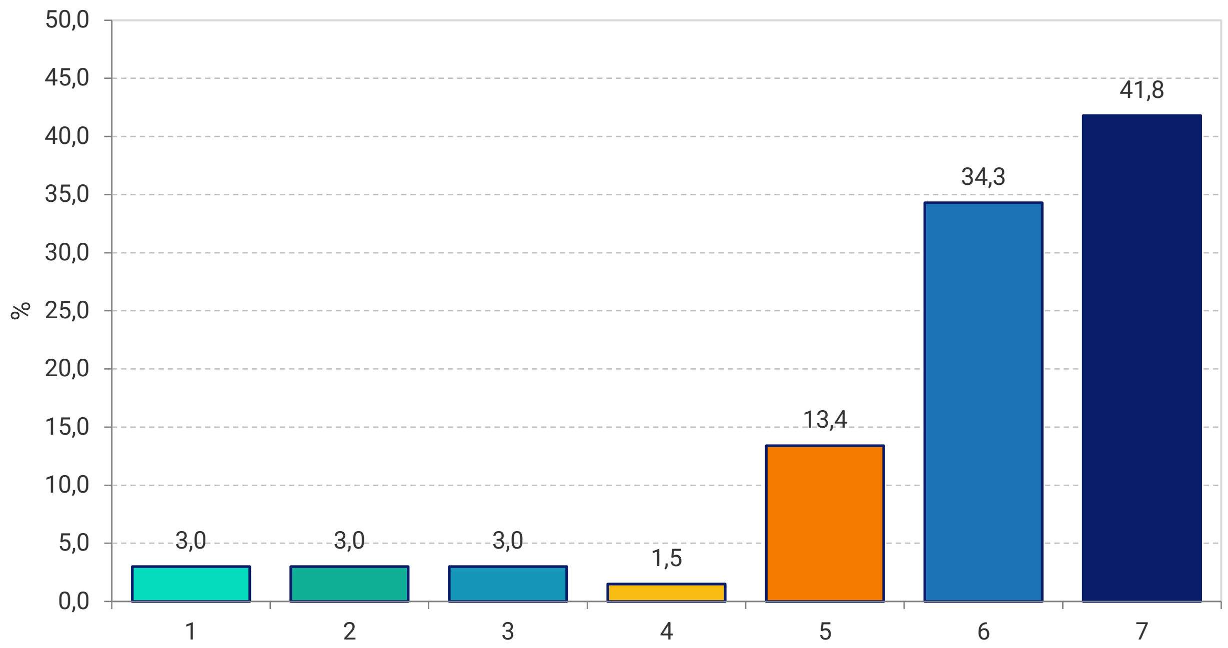

Figure 2-6 Perceived anthropogenic contribution to climate change. 1= mainly natural changes; 7= mainly human activities. Source: REGMURCIA CLIMAAX stakeholder survey, n=67.

Expected impacts and concern levels

Agreement with the expected consequences of climate change is consistently high. Respondents especially agree that environmental emergencies and extreme weather events may have important consequences for economic activities, followed closely by effects on lifestyles and on supply chains or access to products, materials and services. The three items have mean scores above 4.4 on a 1-5 scale, showing a strong shared perception that climate change has systemic implications beyond environmental impacts alone (Table 2-9).

Table 2-9 Agreement with general consequences of climate change.

Item	*Mean*	*High (4-5) %*	*Very high (5) %*
Habits and lifestyles	4.52	89.60	68.70
Economic activities	4.55	91.00	71.60
Supply chains/services	4.46	89.60	65.70

When respondents assess likely future impacts over the next 50 years, the highest score corresponds to the expectation of more natural disasters. Water scarcity also appears as a central concern at both global and local scales. The local water scarcity item reaches a mean of 4.30, confirming that water is perceived as one of the most regionally salient dimensions of climate risk (Figure 2-7).

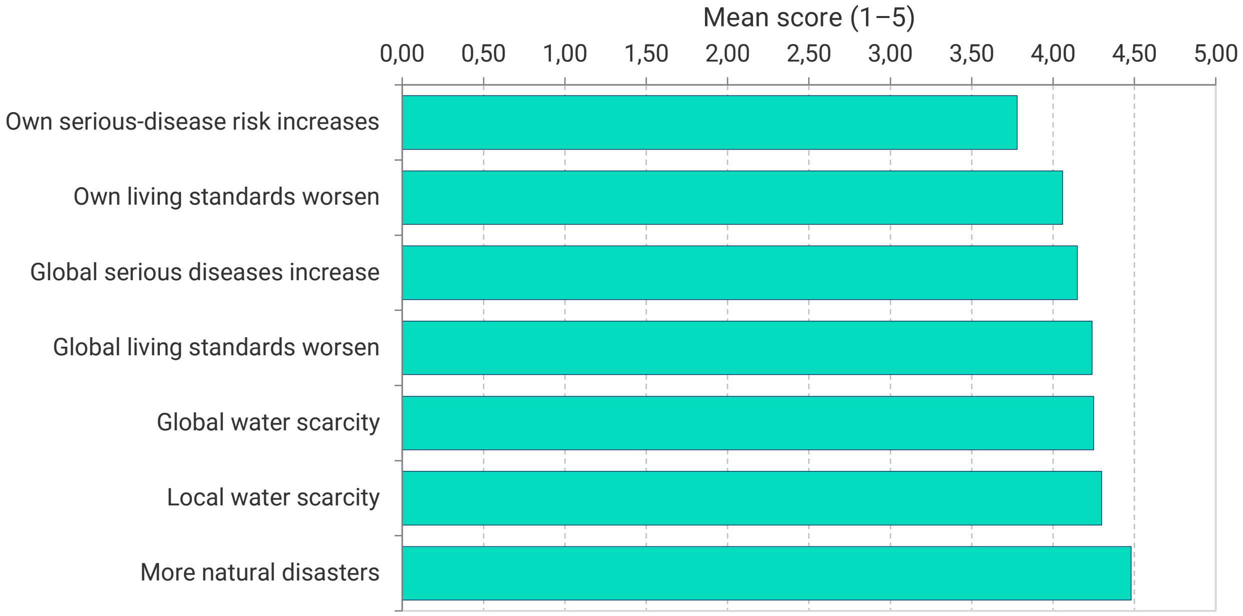

Figure 2-7 Perceived likelihood of climate-change impacts over the next 50 years. Source: REGMURCIA CLIMAAX stakeholder survey.

Concern is also high across all scales of impact. The highest concern refers to nature and ecosystems, with a mean score of 4.45. This is relevant for the Region of Murcia because many of the adaptation measures later prioritised by respondents are linked to ecosystem restoration, water-related ecosystems, natural channels, dunes, wetlands and urban green infrastructure. The concern pattern suggests that stakeholders do not view adaptation only as protection of assets and services, but also as protection of ecological functionality and environmental quality (Figure 2-8).

Figure 2-8 Concern about climate-change impacts. Source: REGMURCIA CLIMAAX stakeholder survey.

Adaptation priorities by climate hazard

The adaptation-measure blocks show very high support across all four hazard families included in the survey: river and pluvial flooding, coastal flooding and sea-level rise, heatwaves, and drought and water scarcity. The average scores for all hazard blocks are above 4.4 on a 1-5 scale. This means that stakeholders do not perceive adaptation as a marginal or optional policy area, but as a broad set of necessary actions (Figure 2-9).

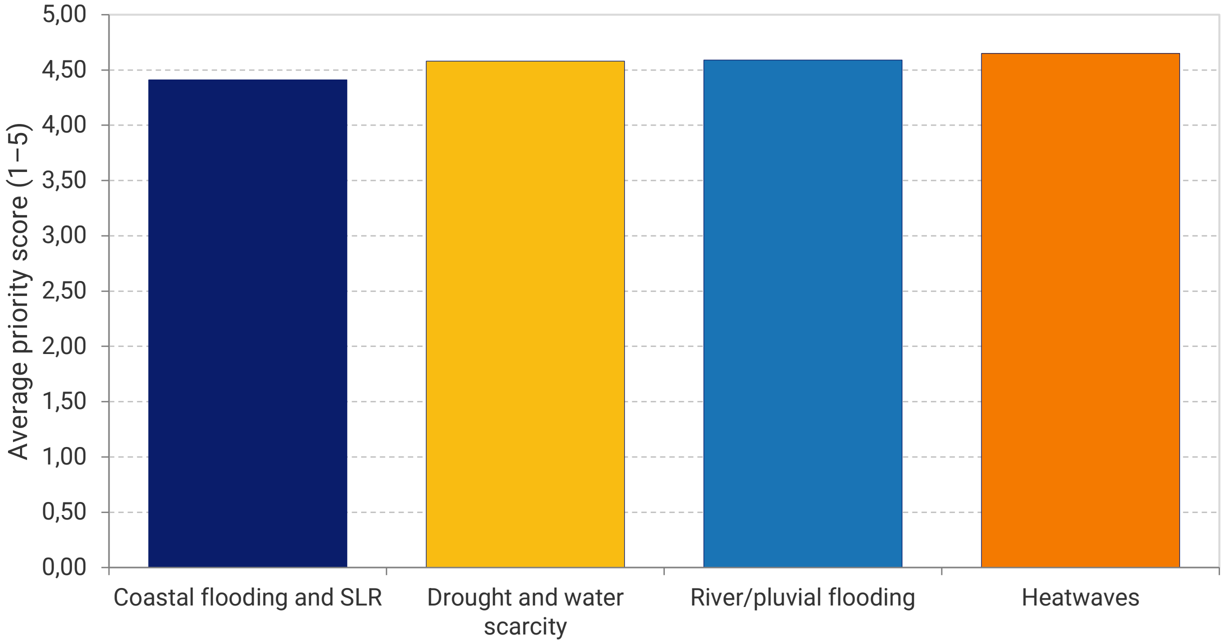

Figure 2-9 Average importance of adaptation measures by hazard. Source: REGMURCIA CLIMAAX stakeholder survey.

Heatwaves obtain the highest average adaptation-priority score, closely followed by river/pluvial flooding and drought/water scarcity. Coastal flooding and sea-level rise also receive high scores, but slightly lower on average. This pattern should not be interpreted as indicating that coastal risk is unimportant. Rather, it may reflect the stakeholder composition of the survey and the fact that heatwaves, drought and intense rainfall are perceived as region-wide concerns, while coastal flooding is spatially concentrated in specific municipalities and economic sectors.

River and pluvial flooding adaptation priorities

For river and pluvial flooding, respondents give highest priority to preventive, planning-oriented and nature-based measures. The most highly rated items are restoration of riverbanks, channels and natural areas; avoidance of new construction in flood-prone or high-risk areas; improvement of early-warning systems; and revision of urban planning to better incorporate flood risk (Figure 2-10).

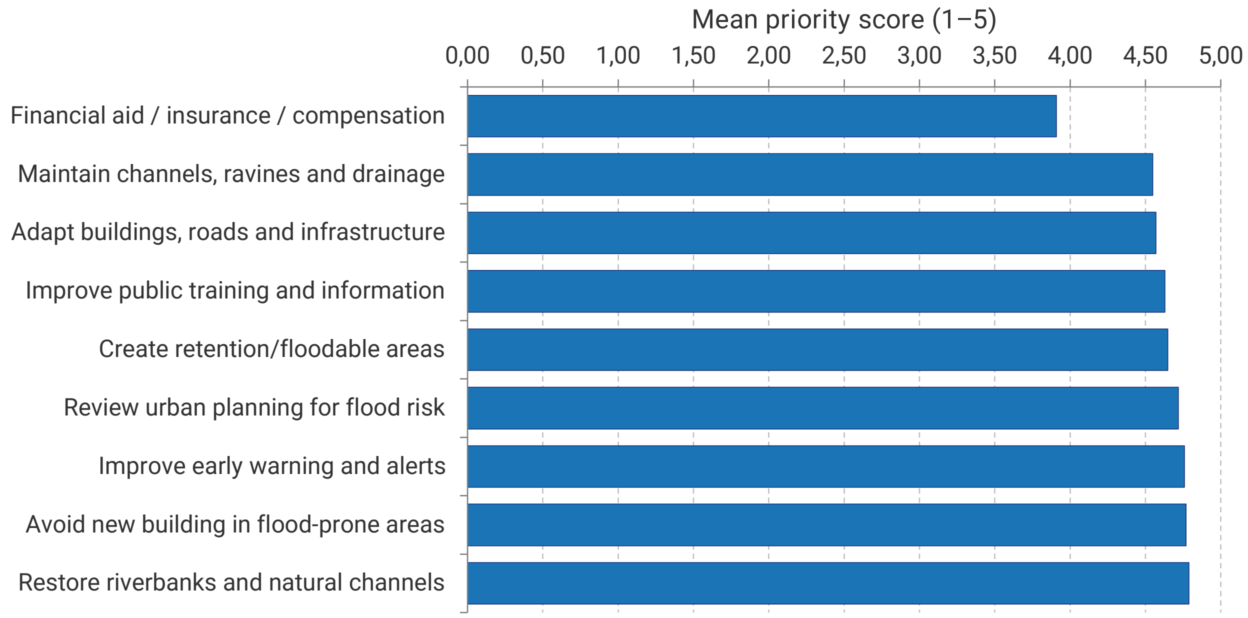

Figure 2-10 River and pluvial flooding adaptation priorities. Source: REGMURCIA CLIMAAX stakeholder survey.

This ranking is highly relevant for the interpretation of flood risk in the Region of Murcia. Stakeholders favour measures that reduce exposure and restore hydrological functionality, rather than relying only on post-event compensation. Economic aid, insurance and compensation receive the lowest average score within the flood block. This does not mean that recovery mechanisms are rejected, but it suggests that they are perceived as less transformative than land-use control, early warning, maintenance, restoration and infrastructure adaptation.

Coastal flooding and sea-level-rise adaptation priorities

For coastal flooding, sea storms and sea-level rise, the highest scores are assigned to restoration of dunes, wetlands, beaches and other natural protective areas, and to avoiding new construction in exposed coastal zones. Review of coastal planning and progressive relocation of certain uses, activities or infrastructure away from the highest-risk areas also receive high levels of support (Figure 2-11).

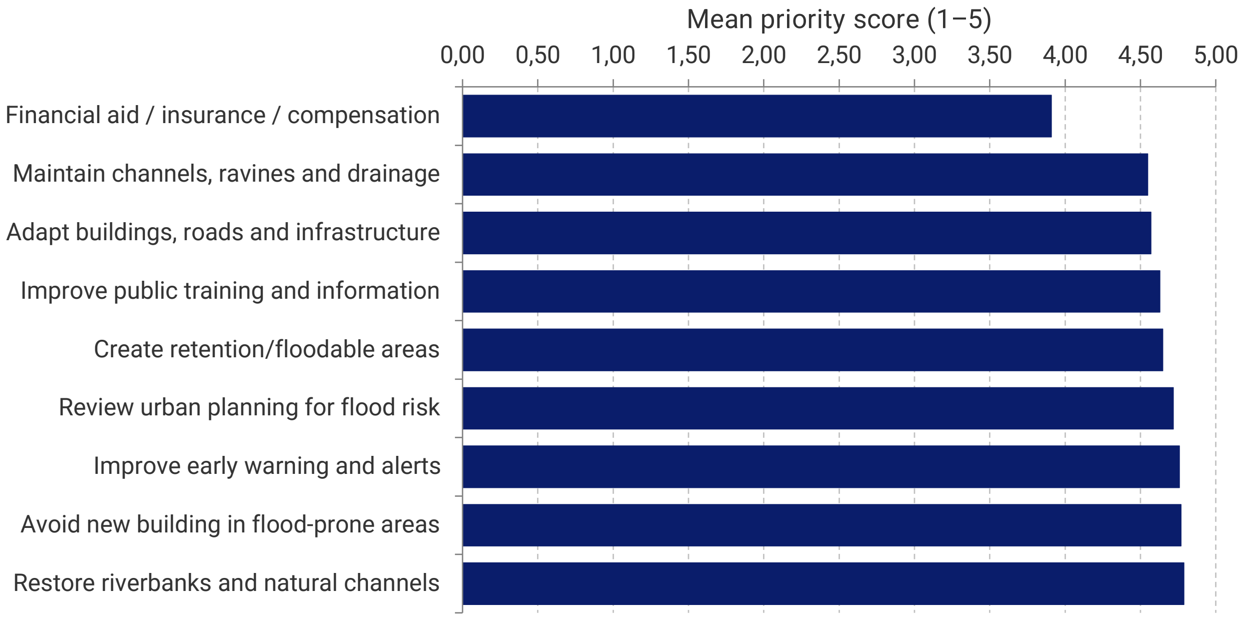

Figure 2-11 Coastal flooding and sea-level-rise adaptation priorities. Source: REGMURCIA CLIMAAX stakeholder survey.

The results indicate a clear preference for anticipatory and spatially preventive coastal adaptation. Hard coastal defences and compensation mechanisms are rated lower than ecosystem restoration, planning revision and avoidance of new exposure. This pattern is consistent with an adaptation logic that prioritises reducing future risk accumulation over maintaining all current uses through engineering or financial compensation alone.

Heatwave adaptation priorities

Heatwave adaptation receives the highest overall average score among the hazard blocks. The strongest priorities are increasing trees, shade, green areas and spaces with water in towns and cities; protecting vulnerable groups; adapting buildings to reduce indoor heat; reducing the urban heat-island effect; and adapting working, school and outdoor activity schedules during extreme heat episodes (Figure 2-12).

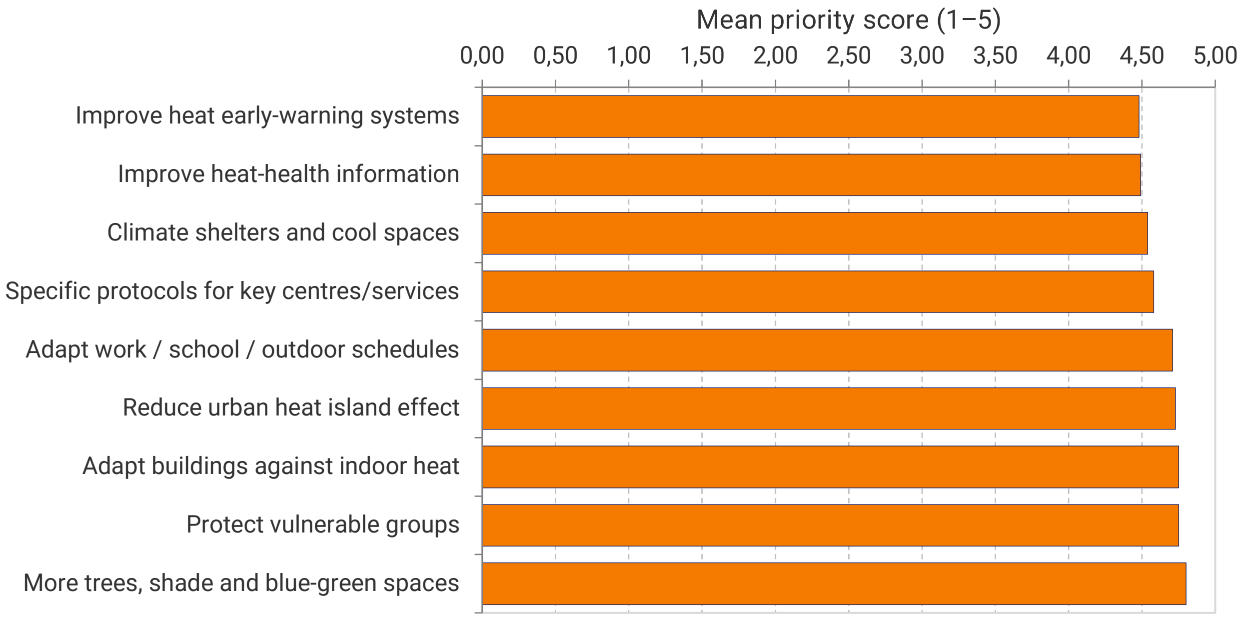

Figure 2-12 Heatwave adaptation priorities. Source: REGMURCIA CLIMAAX stakeholder survey.

These results show that stakeholders understand heatwaves as a combined public-health, urban-design, labour and social-vulnerability challenge. The priority given to vulnerable groups, building adaptation, urban greening and schedule adaptation suggests that heat risk is not perceived only as a meteorological event, but as a social and territorial problem mediated by housing quality, urban form, labour conditions and access to cool spaces.

Drought and water-scarcity adaptation priorities

Drought and water scarcity also receive very high adaptation-priority scores. The leading measures are improving water savings and efficiency across agriculture, industry, tourism, households and public administrations; promoting agricultural practices that conserve soil moisture and reduce erosion; increasing reuse of treated wastewater; protecting and restoring aquifers, wetlands and water-related ecosystems; and modernising irrigation while reducing water-distribution losses (Figure 2-13).

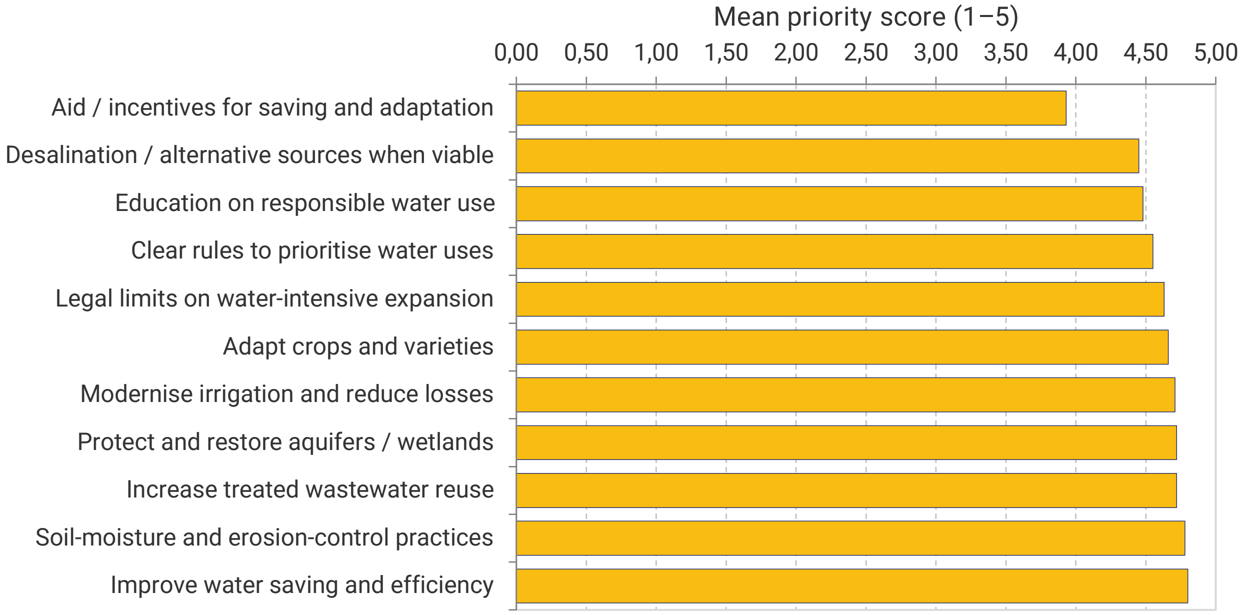

Figure 2-13 Drought and water-scarcity adaptation priorities. Source: REGMURCIA CLIMAAX stakeholder survey.

The results point to a broad understanding of drought adaptation that goes beyond increasing supply. Desalination and alternative sources are rated highly, but not as the top priority. Stakeholders give more importance to efficiency, reuse, soil management, ecosystem restoration, aquifer protection and limits on water-intensive expansion. This suggests that drought adaptation is perceived as a demand-management and territorial-governance issue as much as a water-supply issue.

Highest-priority measures across all hazards

When all adaptation measures are ranked together, the highest-scoring items share several characteristics. They are preventive, spatially explicit, ecosystem-oriented or directly linked to vulnerable populations and essential services. The top-ranked measures include urban greening for heat adaptation, water-saving and efficiency, riverbank and natural-channel restoration, soil-moisture conservation practices, dune and wetland restoration, avoidance of new construction in high-risk areas, and early warning (Figure 2-14).

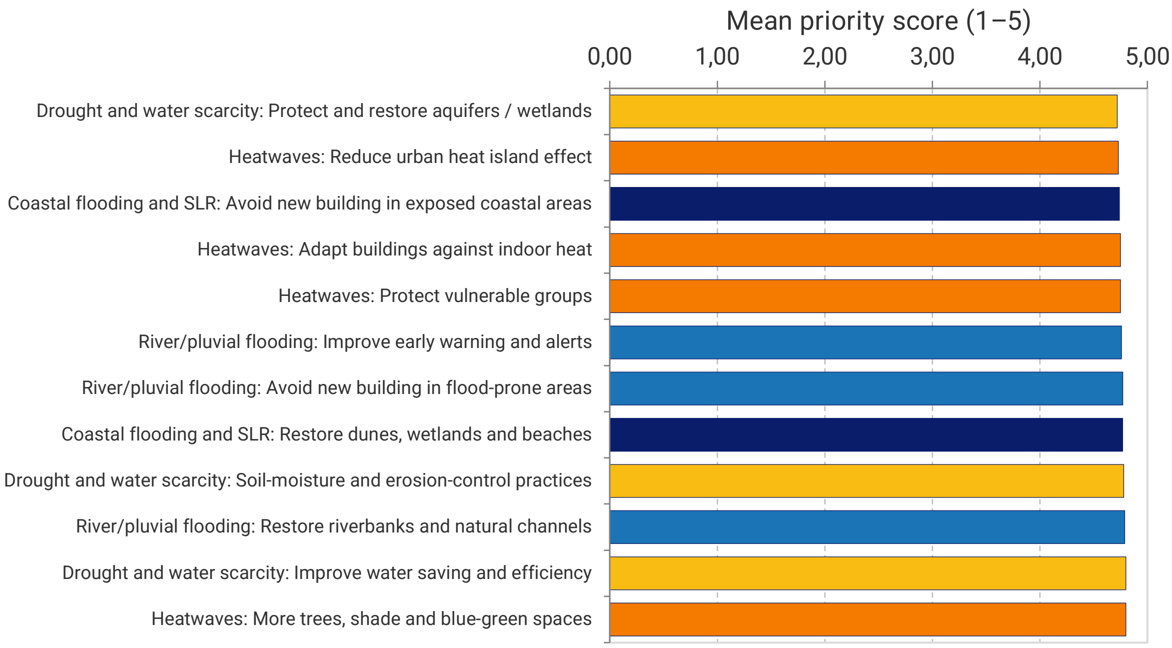

Figure 2-14 Highest-priority adaptation measures across all hazards. Source: REGMURCIA CLIMAAX stakeholder survey.

This cross-hazard ranking is one of the most relevant findings for the future adaptation phase. It suggests that stakeholders favour “no-regret” and “low-regret” measures that can simultaneously reduce exposure, improve environmental quality, support preparedness and avoid further accumulation of risk. Measures focused mainly on compensation or recovery tend to rank lower, indicating that stakeholders expect adaptation to act before damage occurs rather than only after impacts have materialized.

Organisational preparedness: budget and training

The survey reveals a clear gap between high perceived importance of adaptation and limited organisational preparedness. Only 12 response records indicate that the organisation, entity or activity has a specific budget for climate adaptation. Twenty-four indicate no specific budget, while 30 select “do not know / no answer”. This shows that even where climate risk is widely recognised, dedicated financial capacity remains uncertain or insufficiently institutionalized (Figure 2-15).

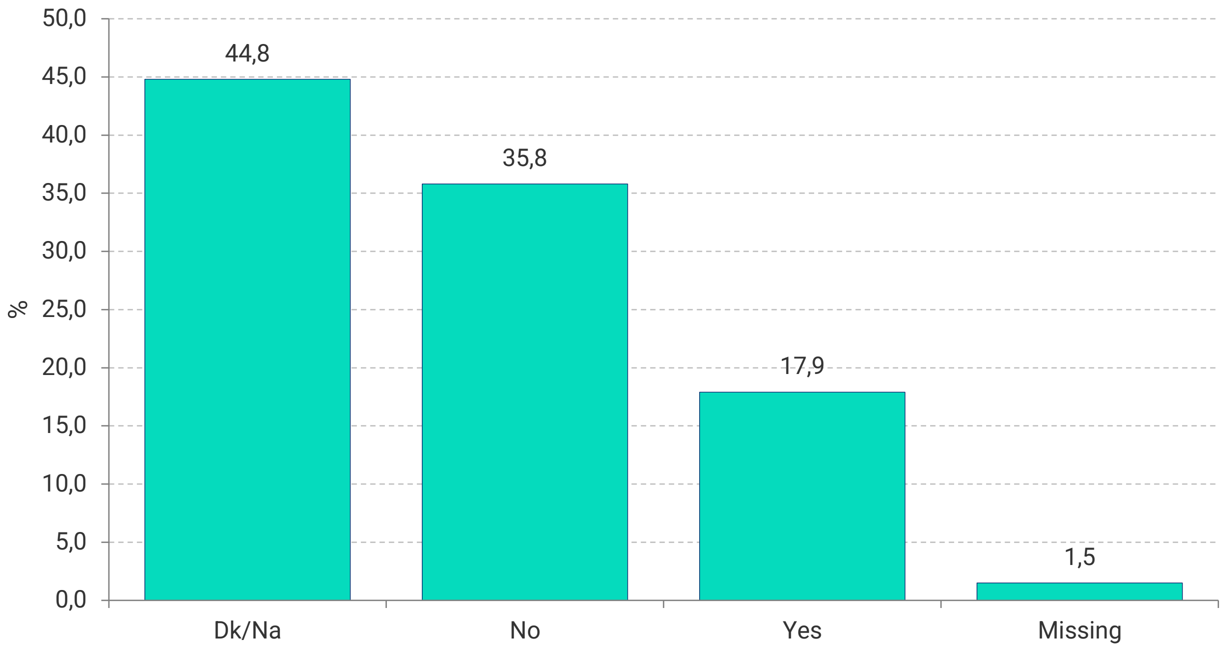

Figure 2-15 Specific budget for climate adaptation. Source: REGMURCIA CLIMAAX stakeholder survey.

Training shows a similar pattern. A large share of respondents either report low levels of staff training or do not know the proportion of trained personnel. Only a minority indicate that more than half of staff have received climate-adaptation training. This finding is important for resilience capacity: adaptation depends not only on plans and data, but also on human capacity, institutional routines and the ability of staff to use climate-risk information in daily decision-making (Figure 2-16).

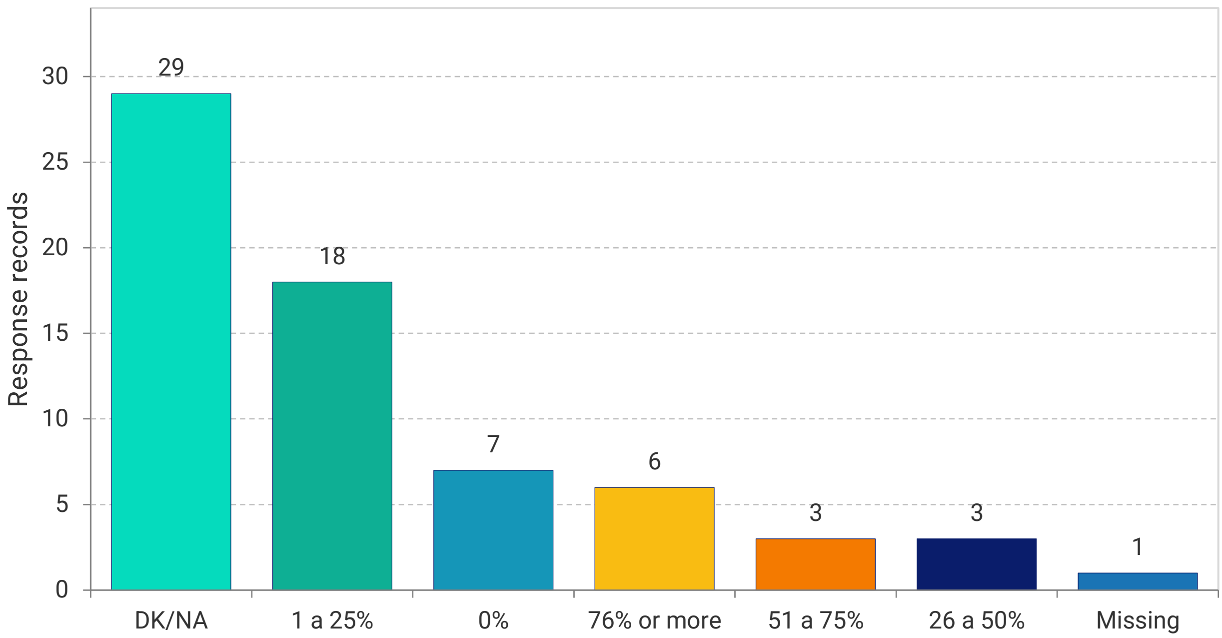

Figure 2-16 Staff training in climate adaptation. Source: REGMURCIA CLIMAAX stakeholder survey.

Monitoring, evaluation and use of climate-risk information

Monitoring and evaluation of adaptation actions appear as one of the weakest areas of the survey. Mean frequency scores are generally between 2.1 and 2.6 on a 1-5 scale. Monitoring scores are slightly higher than evaluation scores, but both remain low. This indicates that many organisations may be aware of climate risks and support adaptation measures, but do not yet have systematic procedures to track whether actions are being implemented or whether they are effective (Figure 2-17).

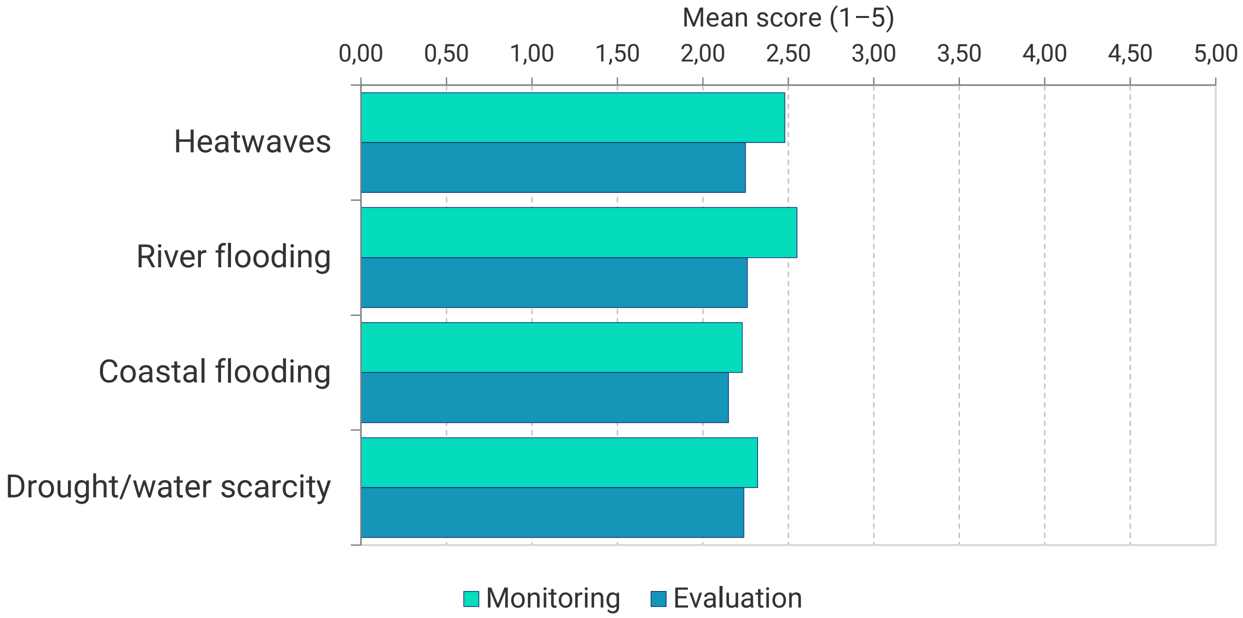

Figure 2-17 Monitoring and evaluation of adaptation actions. Source: REGMURCIA CLIMAAX stakeholder survey.

Use of climate information is moderate. Professional, municipal or sectoral publications receive the highest score among information sources, followed by academic publications, public good-practice guides, international publications and other official sources. The differences are not very large, which suggests that stakeholders rely on a mixed information ecosystem rather than a single dominant source.

The use of maps and technical analyses is uneven. River-flood maps or databases obtain the highest mean score, while heat-island maps, drought maps, vulnerable-population maps and technical vulnerability analyses are used less frequently. This is a key finding for REGMURCIA CLIMAAX. It confirms that spatial climate-risk information exists and is used in some domains, especially flood risk, but it also suggests that other dimensions of vulnerability and adaptation capacity are less operationalized in current institutional practice (Figure 2-18).

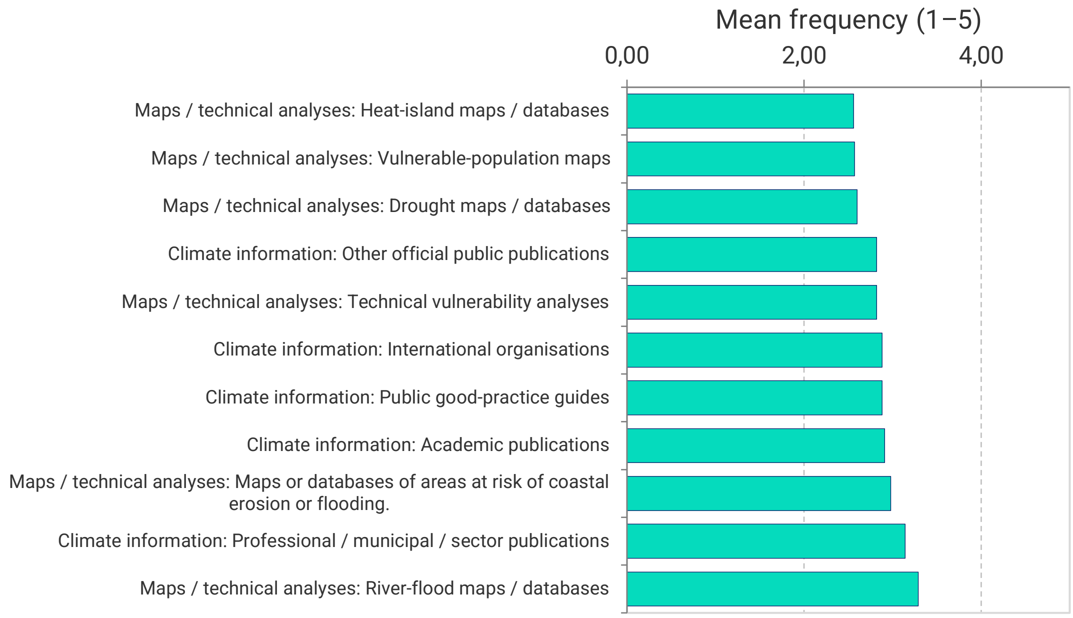

Figure 2-18 Use of climate information, maps and technical analyses. Source: REGMURCIA CLIMAAX stakeholder survey.

Perceived resilience, flexibility and adaptation strategies

Perceived organisational resilience is moderate. The highest score corresponds to the ability to remain alert and well informed, while the ability to respond quickly to climate-related impacts or disruptions receives a lower score. This suggests a difference between awareness and operational capacity. Stakeholders may be relatively attentive to climate risks, but not always equipped to respond rapidly or adapt organisational routines.

The organisational-flexibility items reinforce this interpretation. Questioning outdated practices receives a higher score than flexibility to respond quickly or rapid adaptation when priorities change. In other words, stakeholders appear to recognise the need to change, but institutional procedures, resources and governance arrangements may limit the speed of transformation.

Regarding adaptation strategies, “assessing risks and options” and “accepting and managing risks” receive moderate scores, while “sharing or transferring risks” and “waiting and observing” are lower. This indicates that a purely passive approach is not dominant, but neither is adaptation fully consolidated as a systematic practice. The results point to a transition phase: risk awareness is high, but implementation capacity, monitoring, financing and organisational integration remain incomplete (Figure 2-19).

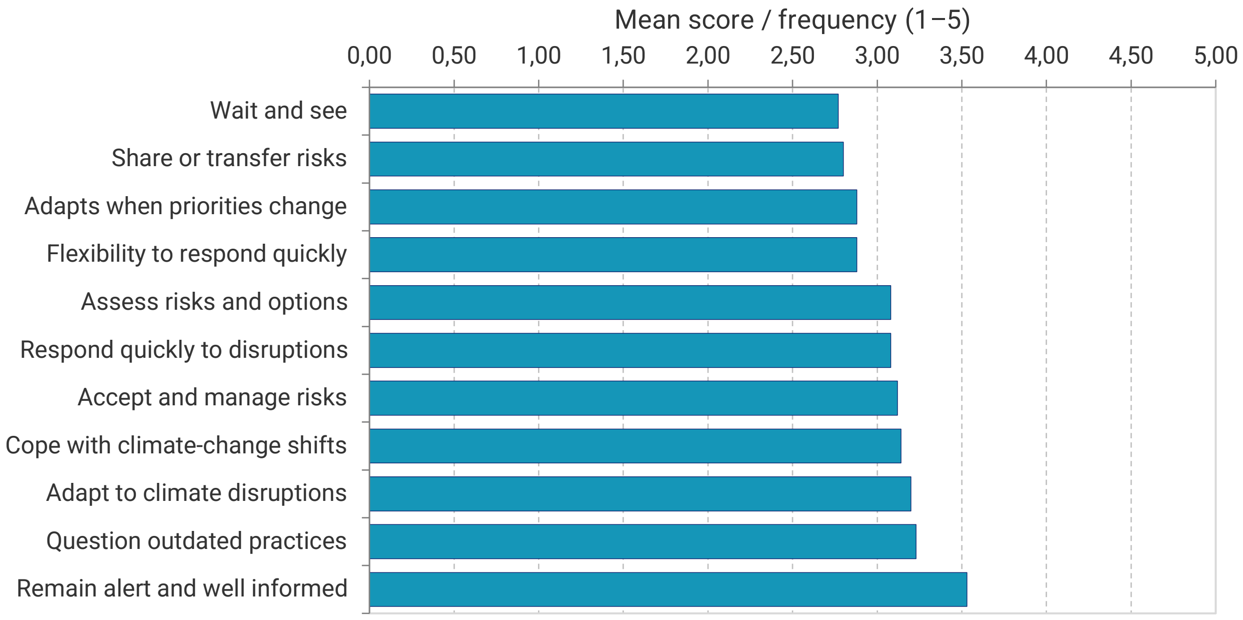

Figure 2-19 Perceived resilience, flexibility and adaptation strategies. Source: REGMURCIA CLIMAAX stakeholder survey.

Stakeholder-group interpretation and inferential patterns

The survey results show a broad consensus around the need for adaptation across all stakeholder groups. Average priority scores for adaptation measures remain high in every macro-group and for every hazard family. This means that the main difference between groups is not whether adaptation is considered important, but which types of risk and which types of measures are emphasised more strongly (Table 2-10 and Figure 2-20).

Table 2-10 Average adaptation-priority indices by stakeholder macro-group.

Stakeholder macro-group	*n*	*Flood*	*Coastal*	*Heat*	*Drought*
Regional administration	33	4.56	4.49	4.71	4.67
Local administration	7	4.62	4.16	4.86	4.61
Knowledge, health and professional bodies	20	4.59	4.32	4.50	4.36
Sectoral, environmental, civil-society and operational actors	7	4.79	4.54	4.65	4.73

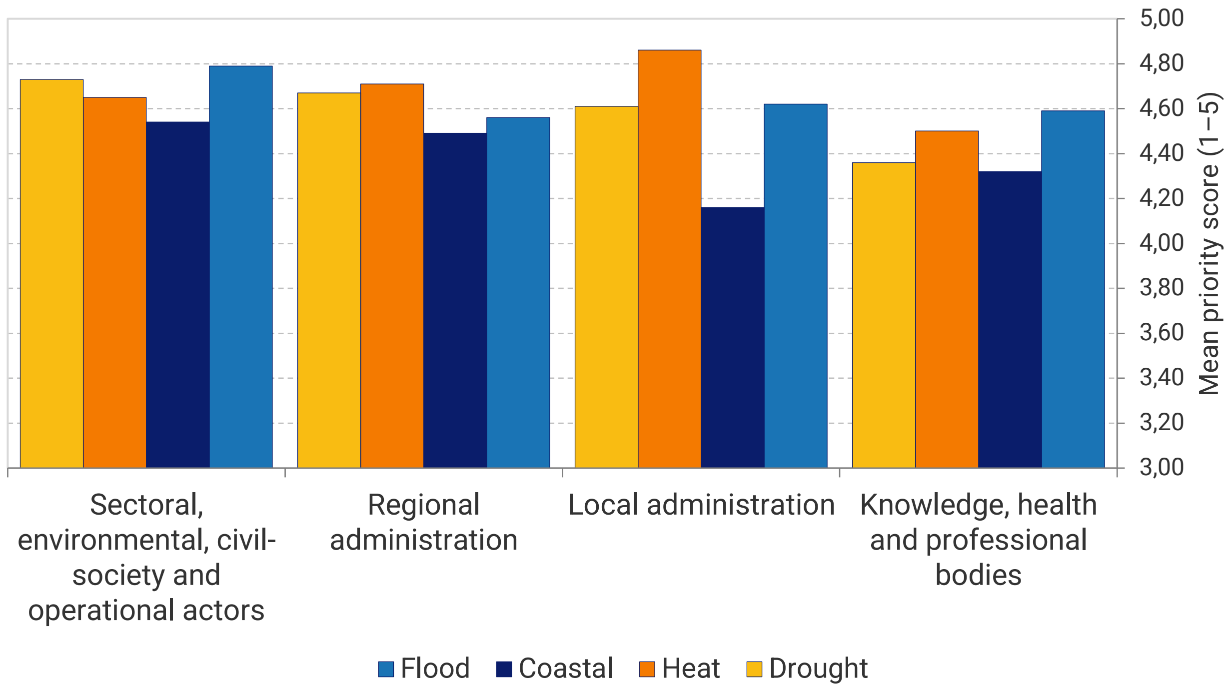

Figure 2-20 Adaptation-priority indices by stakeholder macro-group. Source: REGMURCIA CLIMAAX stakeholder survey, n=67 response records.

Regional administration responses show a balanced but slightly stronger emphasis on heatwaves and drought/water scarcity. The highest-rated measures within this group are water saving and efficiency, treated wastewater reuse, soil-moisture and erosion-control practices, restoration of dunes, wetlands and beaches, protection of vulnerable groups and urban heat-island reduction. This profile is coherent with the regional administration's responsibilities in environmental management, climate policy, water-related planning, territorial regulation and cross-sectoral coordination. It suggests that regional actors tend to frame adaptation as a combination of resource management, ecosystem-based action, spatial regulation and protection of vulnerable groups.

Local administration responses show the strongest concern and future-impact perception among the broad groups. Their highest average score is associated with heatwaves, followed by river/pluvial flooding and drought. The most strongly supported measures include restoration of riverbanks and channels, climate shelters and cool spaces, adaptation of buildings against indoor heat, heat-health information, review of urban planning for flood risk and creation of retention or floodable areas. This pattern suggests that municipalities are particularly sensitive to direct service-delivery pressures: urban heat, public-space design, buildings, local drainage, emergency communication and proximity to exposed populations.

Knowledge, health and professional bodies give comparatively strong emphasis to planning, preventive regulation and information. Their top priorities include avoiding new construction in flood-prone areas, reviewing coastal planning for sea-level rise, increasing trees and green-blue spaces, adapting buildings against heat, early warning and public training. Their scores for monitoring/evaluation and information use are lower than their adaptation-priority scores. This suggests a gap between expert or professional awareness of what should be done and the operational capacity or institutional routines needed to monitor, evaluate and use climate-risk information systematically.

The aggregated group of sectoral, environmental, civil-society and operational actors gives very high scores to river/pluvial flooding and drought/water scarcity, with strong support for restrictive land-use planning, early warning, public training, coastal-risk information and soil-moisture/erosion-control practices. Because this is an internally diverse group and includes small subcategories, the result should be interpreted cautiously. Even so, it indicates that actors outside the core regional administration tend to emphasise preventive regulation, risk communication and concrete territorial measures.

Overall, the inter-group pattern points to complementarity rather than contradiction. Regional administration tends to emphasise strategic resource and ecosystem management; local administrations emphasise operational and urban adaptation; knowledge and professional bodies emphasise planning, prevention and information; and sectoral/civil-society actors emphasise regulatory prevention, risk communication and water/soil management. This diversity is useful for the Climate Risk Assessment because it reflects the multi-level governance structure of adaptation in the Region of Murcia.

Capacity and implementation gap by stakeholder group

The most relevant inferential result is the contrast between high adaptation-priority scores and lower implementation-capacity indicators. This gap appears across all stakeholder groups. While respondents rate adaptation measures as highly important, the reported frequency of monitoring, evaluation, information use and formal adaptation strategies is more moderate or low (Figure 2-21).

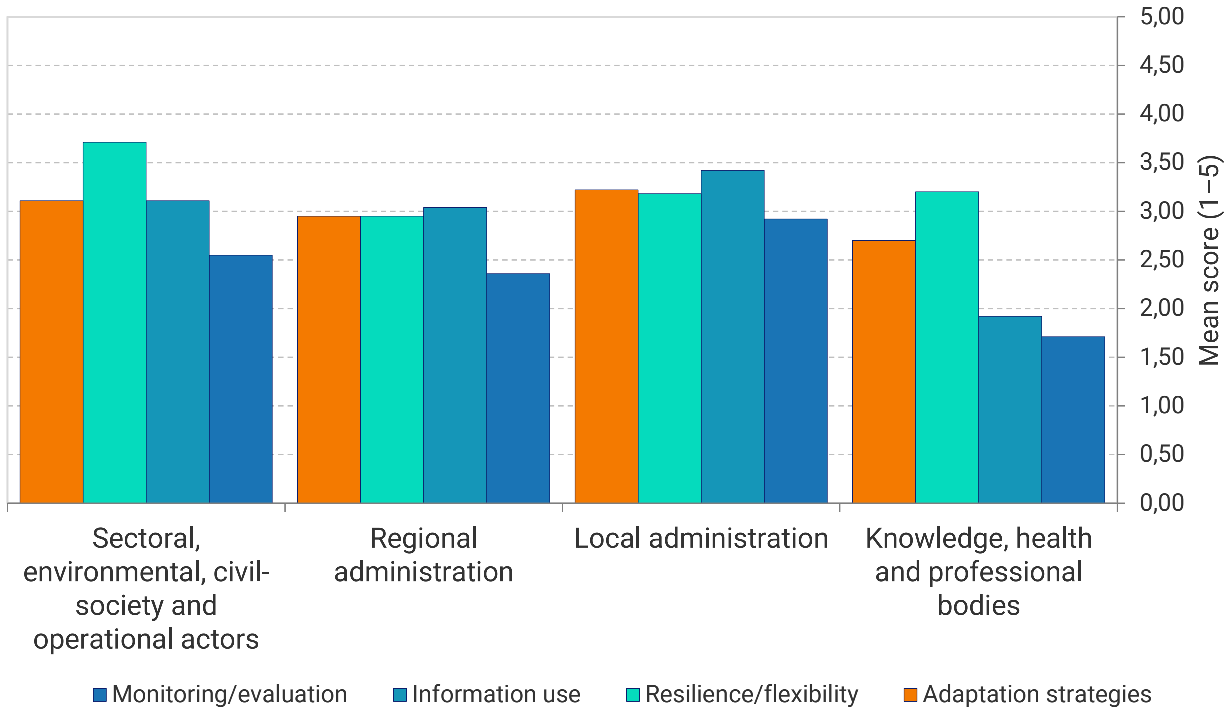

Figure 2-21 Implementation-capacity indices by stakeholder macro-group. Source: REGMURCIA CLIMAAX stakeholder survey, n=67 response records.

Local administrations report the highest use of climate information and the highest monitoring/evaluation score among the four macro-groups. This is relevant because municipalities are closer to the day-to-day management of urban heat, drainage, public spaces, local emergency response and citizen communication. However, even in this group, the monitoring/evaluation index remains below the very high scores assigned to adaptation measures. This suggests that local actors recognise climate risk and some operational tools are already used, but the transition towards systematic evaluation of adaptation measures remains incomplete.

Regional administration responses show relatively high information-use scores but lower resilience/flexibility and monitoring/evaluation indices than would be expected given their central role in climate policy. This should not be interpreted as lack of institutional awareness. Rather, it points to the complexity of embedding adaptation into routine administrative practice across multiple departments, regulations and planning instruments. The implication for Phase 3 is that adaptation options should not only identify technical measures, but also specify monitoring indicators, responsible units, data flows and follow-up mechanisms.

Knowledge, health and professional bodies show one of the largest gaps between high concern and lower reported implementation capacity. This is important because these actors can provide scientific, technical, professional or social knowledge, but they may not always control the resources or mandates required to implement adaptation measures. Their role in Phase 3 may therefore be especially valuable in knowledge transfer, technical validation, professional guidance, training and monitoring support.

The sectoral, environmental, civil-society and operational group shows the highest resilience/flexibility score, but the group is small and heterogeneous. This may reflect the greater adaptability of smaller or more mission-oriented organisations, or the operational experience of actors directly exposed to environmental risk. It should not be used to generalise to all sectoral or civil-society actors, but it does support the value of including them in later validation workshops and adaptation-design discussions.

A second capacity gap concerns budgets and training. At the whole-sample level, only 12 response records reported a specific adaptation budget, while 24 reported no budget and 30 selected do not know/no answer. Training shows a similar pattern: most responses either report low training coverage or do not know the proportion of staff trained. This reinforces one of the main governance conclusions of the survey: adaptation is widely perceived as necessary, but it is not yet consistently institutionalised through dedicated budgets, staff training, monitoring systems and evaluation routines.

Implications for risk prioritisation and Phase 3

The inferred group differences have several implications for the next stages of REGMURCIA CLIMAAX. First, future prioritisation should avoid treating stakeholder perception as a single homogeneous signal. Regional, local, technical, social, environmental and sectoral actors emphasise different dimensions of the same risks. This makes the stakeholder evidence particularly useful for interpreting severity, urgency and resilience capacity.

Second, the high cross-group priority given to heatwaves, drought/water scarcity and river/pluvial flooding suggests that these hazards should remain central in the participatory interpretation of the regionalised risk analysis. Coastal flooding and sea-level rise also receive high scores, but their prioritisation appears more dependent on the territorial or institutional position of each respondent. This is consistent with the spatially concentrated but potentially severe character of coastal risk.

Third, adaptation measures that appear repeatedly across groups should be considered strong candidates for Phase 3 discussion: water saving and reuse, urban heat adaptation, protection of vulnerable groups, nature-based solutions, land-use planning in exposed areas, early warning, public information, maintenance/restoration of watercourses and integration of future climate scenarios into planning. These measures combine broad stakeholder support with direct relevance to the hazards addressed by the project.

Fourth, the main weakness identified by inference is not lack of awareness, but the implementation gap. The survey suggests that adaptation is recognised as necessary, but dedicated resources, training, monitoring, evaluation and institutional routines remain uneven. For this reason, Phase 3 should distinguish between technical adaptation measures and enabling measures such as governance arrangements, data systems, inter-administrative coordination, staff training and monitoring frameworks.

Optional open responses: thematic analysis

The optional open question asked respondents to indicate additional adaptation measures not covered by the closed blocks on flooding, coastal risk, heatwaves, drought and sea-level rise. Twenty respondents provided free-text input. Individual responses are not reproduced in order to preserve confidentiality, but the content was coded thematically. The themes below should be interpreted as qualitative signals rather than as statistically weighted preferences (Table 2-11).

Table 2-11 Aggregated themes from optional open responses.

Theme	*Mentions*	*Interpretation*
Early warning, protocols and risk communication	4	Calls for stronger meteorological alert networks, operational severe-weather protocols and communication to the population before and during extreme events.
Heat adaptation in work, schools and buildings	4	References to adapting working and school schedules, teleworking during heat episodes, improving thermal conditions in schools and providing suitable equipment for outdoor workers.
Technical/scientific governance and inter-administrative coordination	4	Requests for decisions to be based on technical/scientific criteria, better professional training, depoliticisation of decision-making and stronger coordination between administrations.
Water governance, demand management and local water infrastructure	4	Proposals on water transfers, restrictions in overexploited aquifers, recovery of traditional water infrastructure, rainwater harvesting and more restrictive regulation of water-intensive uses.
Energy transition and behavioural measures	3	References to solar photovoltaic access in collective buildings, sustainable cooling, responsible use of air conditioning and measures reducing mobility-related emissions.

Land-use planning, responsibility and retreat from exposed areas	3	Emphasis on integrating future climate scenarios into flood zoning, avoiding or removing infrastructure in flood-prone and coastal-risk areas and assigning responsibility for risky planning decisions.
Nature-based solutions and urban/environmental quality	3	Support for nature-based solutions, naturalised parks, green areas, protected spaces, reduced pollution and ecological restoration as adaptation measures.
Communication framing and public acceptance	1	One minority contribution warned against alarmist communication while supporting rigorous climate-risk work.
Financing and investment for adaptation in public facilities	1	Specific request for funding to improve cooling and thermal insulation in educational facilities using sustainable and efficient systems.

The open responses reinforce and nuance the closed-question results. Several contributions insist on early warning, risk communication and operational protocols. This goes beyond generic awareness-raising: respondents refer to the need for alert systems and protocols that trigger concrete protective actions during severe weather, heat or flood episodes. This is directly relevant to the urgency and resilience-capacity dimensions of the CLIMAAX Key Risk Assessment.

A second recurring theme is heat adaptation in everyday public and work environments. Respondents refer to teleworking, adaptation of school and work schedules, thermal improvement of educational facilities, sustainable cooling and protection of outdoor workers. These contributions are important because they translate heat risk into operational decisions affecting labour conditions, schools, public buildings and service continuity. They also indicate that heatwaves are not perceived only as a health emergency, but as a governance and infrastructure issue.

Water governance appears in several comments through different angles: water transfers, restrictions in overexploited aquifers, recovery of traditional water infrastructure, rainwater harvesting, retention and infiltration in forest areas, and restrictions on highly water-consuming activities. The common thread is that drought and water scarcity are perceived not only as a meteorological hazard, but as a territorial-management and demand-governance challenge.

Another strong qualitative signal concerns technical and scientific governance. Several responses request that climate adaptation decisions be based on technical evidence, scientific criteria and real inter-administrative coordination. These comments often express concern about political interference, fragmentation or lack of professional training. This theme supports the conclusion that the acceptability of adaptation measures may depend on transparency, technical credibility and coordination between responsible institutions.

Land-use planning and retreat from exposed areas also emerge clearly. Some respondents refer to integrating future climate scenarios into flood-zone delimitation, avoiding new development in exposed areas, removing infrastructure located in fluvial or coastal risk zones instead of repeatedly repairing it, and assigning responsibility where planning decisions increase exposure. This qualitative evidence is especially relevant for the later comparison with flood and coastal-risk modelling outputs.

Nature-based solutions and environmental quality are also present. Respondents mention naturalised parks, green areas, protected spaces, reduced emissions and nature-based solutions as measures with lower implementation costs and better medium- to long-term performance. This theme connects climate-risk reduction with broader environmental quality and ecosystem restoration.

Finally, a small number of responses refer to energy transition and behavioural measures, such as facilitating photovoltaic installations in collective buildings or promoting responsible air-conditioning use. One minority response warns against alarmist communication while supporting rigorous work. This last point is useful because it reminds the project that risk communication must be technically robust, clear and proportionate if it is to support public acceptance rather than polarisation.

Synthesis of additional inferential findings

The additional analysis supports six main conclusions. First, stakeholder groups differ more in emphasis than in overall direction: all groups assign high importance to adaptation. Second, local administrations appear particularly concerned with operational urban risks, especially heat and local flood management. Third, regional administration responses point towards strategic measures related to water, ecosystem restoration, vulnerable groups and planning. Fourth, knowledge, health and professional bodies provide strong support for preventive planning, information and technical guidance, but appear less directly linked to implementation routines. Fifth, the open responses show that stakeholders expect adaptation to include governance reforms, protocols, training, financing and accountability, not only physical measures. Sixth, the most important cross-cutting gap is implementation capacity: budgets, training, monitoring and evaluation are not yet aligned with the high perceived importance of adaptation.

These findings should be used as a qualitative-inferential layer in the final triangulation with the regionalised risk modelling. In particular, they can help explain why some hazards may be perceived as more urgent by certain actors, why some technically relevant risks may require stronger communication, and which adaptation measures are more likely to obtain institutional and social support in Phase 3.

Semi-structured interviews: results and qualitative validation

Eight semi-structured interviews were analysed. The interviews cover agriculture, tourism, meteorological observation, spatial planning, municipal climate action, social vulnerability and technical-scientific agroclimatic knowledge. Although the final number of interviews is lower than the initial target, the sample remains highly relevant for the objectives of Phase 2 because the interviewed entities occupy key positions in regional climate-risk governance and provide complementary sectoral, technical and institutional perspectives.

The analysis combines qualitative interpretation and systematic content coding. The full coding matrices used to support this systematic content analysis are provided in Annex-REGMURCIA_CLIMAAX-Quantitative coding matrices. They reproduce the exploratory scores assigned to the substantive interview content and provide traceability between the qualitative interpretation, the coded figures and the preliminary stakeholder-based prioritisation. Non-substantive elements generated by the online interview format, including greetings, connection issues, audio checks, informal remarks, procedural explanations and interviewer repetitions, were filtered out before analysis. The coding should not be interpreted as inferential statistics. The interviews constitute a targeted qualitative sample and are used to organise expert evidence, identify recurring priorities and validate the interpretation of the regional Climate Risk Assessment.

Statistical and qualitative confidentiality has been preserved. The section does not reproduce personal comments or identify individual respondents beyond the institutional level already used in the stakeholder methodology. Direct quotations are not included. Instead, the analysis presents aggregated themes, synthetic coding results and interpreted findings relevant to the CLIMAAX assessment.

The interview evidence is highly valuable but has limitations. The sample is intentional and not statistically representative. Some relevant actors remain underrepresented, especially basin and water management, public health, emergency management/civil protection, critical infrastructure and environmental civil society. These limitations should be made explicit in the D2, not as a weakness of the current analysis, but as guidance for subsequent validation and Phase 3 engagement.

Stakeholder sample and analytical coverage

The current sample provides strong coverage in agriculture/drought, flood risk and spatial planning, heat and social vulnerability, and local meteorological knowledge. Coverage is more limited for basin and water management, formal public health, institutional emergency management, coastal and port governance, critical infrastructure and environmental civil society (Table 2-12). These gaps do not invalidate the findings, but they delimit the scope of the interview evidence and identify actors that should be prioritised in future validation or Phase 3 engagement.

Table 2-12 Interviewed stakeholders and analytical contribution to Phase 2.

Entity	*Type of actor*	*Main value for Phase 2*
ITREM	Tourism-sector administration	Tourism, deseasonalisation, coastal areas, heat, tourism demand, social and environmental sustainability.
AMETSE	Meteorological association / territorial expert knowledge	Local meteorological observation, early warning, ephemeral streams, torrential rainfall and heatwaves.
Local Energy and Climate Change Agency, Murcia City Council	Local administration	Energy, municipal adaptation, citizen participation, funding and urban projects.
DG IMAS	Social administration / vulnerable centres	Social vulnerability, care homes, occupational centres, air conditioning, evacuation and public buildings.
DG Food Industry and Agricultural Associations	Agricultural administration	Drought, dryland farming, agricultural insurance, production losses and agricultural statistics.
DG Spatial Planning and Architecture	Territorial administration	Planning, flood-prone areas, coastline, territorial guidelines and regional planning instruments.
FECOAM	Agricultural cooperative federation	Drought, dryland farming, irrigation, generational renewal, profitability and cross-cutting policies.

IMIDA	Agricultural technical-scientific centre	Agroclimatic data, SIAM network, crops, varieties, drought, heat, hail, frost and modelling.

The interviews confirm the relevance of the main hazards selected in REGMURCIA CLIMAAX: drought, river and coastal flooding, and heatwaves. They also refine their interpretation by showing how each risk is expressed differently depending on sector, territory, institutional responsibility and capacity to act.

General perception of climate change

The general conclusion is that the Region of Murcia is already experiencing operational consequences consistent with climate change or with intensified climate variability. The language used by stakeholders differs. Some actors refer explicitly to climate change, while others are more cautious about terminology or the degree of alarmism. However, even cautious interviewees recognise observable effects: higher temperatures, altered crop calendars, production losses, drought pressure, torrential rainfall, flood exposure, coastal erosion, infrastructure stress and administrative difficulties in adapting quickly enough.

This distinction is relevant for the D2 because acceptance of climate-change terminology is not the only indicator of risk awareness. The interviews validate the existence of sectoral and institutional problems that require adaptation regardless of how each actor frames the underlying climate process.

The word cloud (Figure 2-22) provides a synthetic visual overview of the main concepts associated with climate-change perception in the stakeholder interviews. The prominence of terms such as climate change, risk, impact, flooding, drought, temperature, agriculture, water, vulnerability and adaptation indicates that stakeholders do not describe climate change as an abstract or distant phenomenon. Instead, they connect it directly with concrete hazards, exposed sectors and operational adaptation needs.

The strong presence of flooding and drought confirms the central role of hydrological extremes in the regional perception of climate risk. Stakeholders refer both to structural water scarcity and drought, and to torrential rainfall, ephemeral streams and flood-prone areas. At the same time, terms such as temperature, heat, heatwaves and cooling highlight the growing importance of extreme heat, particularly in relation to health, public buildings, outdoor work, tourism and urban liveability.

The figure also shows the relevance of agriculture-related terms, including agriculture, dryland, crops, irrigation and insurance. This reflects the importance of agricultural vulnerability in the Region of Murcia, especially regarding dryland farming, crop losses, profitability and risk-transfer mechanisms. In parallel, words such as territory, coast, tourism, facilities, buildings, social and governance show that interviewees link climate impacts with spatial planning, coastal management, public services, social vulnerability and institutional capacity.

Overall, the word cloud reinforces one of the main findings of the qualitative analysis: stakeholders perceive climate change as a cross-cutting risk affecting water, agriculture, territory, infrastructure, tourism, social services and governance. This supports the need for a Climate Risk Assessment that combines hazard analysis with exposure, vulnerability, preparedness and institutional adaptation capacity.

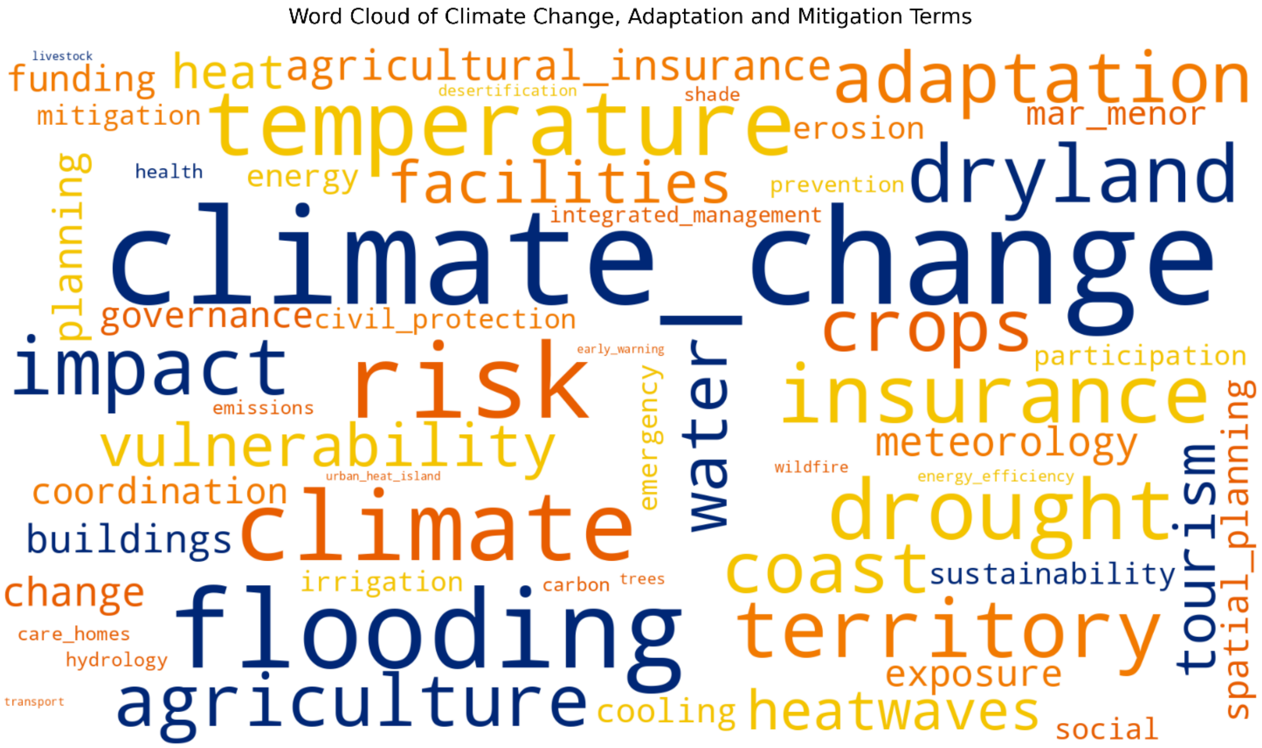

Figure 2-22 Word cloud of recurrent terms associated with climate-change perception in the stakeholder interviews.

Priority climate risks

Drought appears as the most structural sectoral risk, particularly in relation to dryland systems. Flooding is interpreted not only as a hydrological hazard, but also as a planning and governance issue shaped by land occupation, ephemeral streams, exposure accumulation and warning capacity. Heatwaves appear as a multi-sectoral risk affecting health, care facilities, public buildings, outdoor workers, agriculture, tourism and urban liveability (Table 2-13).

Table 2-13 Priority climate risks identified through the interviews.

Risk	*Stakeholders reinforcing it*	*Cross-cutting interpretation*
Drought and water scarcity	DG Food Industry, FECOAM, IMIDA	Structural agricultural risk, especially for dryland farming, woody crops and extensive livestock.
Heatwaves	AMETSE, IMAS, IMIDA, ITREM, Local Agency	Health, labour, urban, tourism and agricultural risk.
Torrential rainfall and flooding	AMETSE, Spatial Planning, IMAS, Local Agency, ITREM, IMIDA	Territorial and governance risk; especially relevant for ephemeral streams, Campo de Cartagena, metropolitan Murcia and coastal areas.

Coastal flooding and erosion	ITREM, Spatial Planning	Relevant for tourism, coastline, Mar Menor and coastal planning.
Hail and frost	IMIDA, DG Food Industry	Agroclimatic risks not central in the initial hazard triad but important for agriculture and insurance.
Desertification and abandonment	FECOAM, DG Food Industry	Compound risk associated with dryland farming, erosion, profitability and generational renewal.

Current and expected impacts

The interviews show that climate impacts are already being perceived in very concrete and operational terms across the main sectors consulted. In agriculture, stakeholders refer not only to drought as a general climatic pressure, but to its effects on dryland productivity, crop calendars, exposure to hail and frost, agricultural insurance, production costs and profitability. This is important because it frames drought as a structural territorial risk, especially for woody crops, cereals, vineyards, almond, olive and extensive livestock, rather than as a temporary water-shortage episode. In tourism, the evidence is more nuanced: stakeholders do not describe an immediate collapse of summer demand, but they do point to a gradual need for diversification, deseasonalisation and adaptation of destinations, accommodation and coastal infrastructure. Climate risk in tourism therefore appears as a process of spatial and seasonal reconfiguration, linked to heat, coastal pressure and sustainability.

The interviews also make clear that some impacts are strongly mediated by social vulnerability and institutional capacity. Heat is particularly relevant for care homes, occupational centres, social centres and public buildings, where air-conditioning failures, lack of redundancy or delayed maintenance can directly affect dependent populations. Flooding and coastal erosion are interpreted not only as physical hazards, but also as planning and governance problems, shaped by accumulated exposure, land-use decisions and the slow development of preventive instruments. At the same time, emergency and warning systems emerge as a critical area, especially for torrential rainfall and ephemeral streams, where dense real-time meteorological information and rapid communication can make a substantial difference. Finally, municipal action appears constrained by administrative capacity, funding stability and the ability to translate climate-risk awareness into executable projects. Taken together, these findings show that the expected evolution of risk will depend not only on future hazard intensity, but also on whether governance, planning, maintenance, funding and local implementation capacity improve over time (Table 2-14).

Table 2-14 Current and expected impacts emerging from the interviews.

Domain	*Current impacts mentioned*	*Expected future evolution*
Agriculture	Production decline in dryland farming; crop calendar shifts; hail/frost exposure; pressure on agricultural insurance; rising costs and loss of profitability.	Greater instability for dryland woody crops, cereals, vineyards, almond, olive and extensive livestock; abandonment and erosion risks.
Tourism	No clear immediate drop in summer demand, but increasing need for diversification, deseasonalisation and adaptation of destinations.	Spatial and temporal reconfiguration of demand; increased costs for accommodation and coastal infrastructure; sustainability pressure.

Social services	Heat vulnerability in care homes, occupational centres, social centres and public facilities; air-conditioning failures as operational risk.	Greater exposure of dependent populations; need for climate-proofing, redundancy and maintenance of public buildings.
Territory and planning	Flood-prone areas, exposed uses, conflicts between planning and land occupation, coastal erosion and delayed guidelines.	Accumulated exposure may increase damage even where hazard frequency is uncertain; need for stricter preventive planning.
Emergency and warning systems	Need for proximity meteorological data and rapid communication for torrential rainfall and ephemeral streams.	Dense real-time monitoring may become a critical component of preparedness for flash-flood events.
Municipal action	Difficulty translating climate awareness into citizen participation, project design and funding execution.	Municipal adaptation will depend on administrative capacity, stable funding and usable climate-risk outputs.

Preparedness, response capacity and governance barriers

Preparedness is uneven. The interviews identify relevant capacities, including historical experience with floods, meteorological and agroclimatic networks, SAIH/CHS, SIAM, local weather stations, scientific knowledge, strategic plans, European funds and specialised technical teams. However, the same interviews repeatedly show that these capacities do not automatically translate into implementation.

The most recurrent constraints are institutional fragmentation, shortage of technical staff, complex public procurement and aid procedures, dependence on temporary funding, slow administrative processing, low citizen participation, weak translation of diagnosis into executable projects and mismatch between the speed of climate impacts and the speed of administrative response. This is a central result for the CLIMAAX Key Risk Assessment because resilience capacity depends not only on knowing where risks are located, but also on whether institutions can act in time.

Quantitative content analysis of the interviews

A quantitative content analysis was carried out to support the qualitative interpretation. Each interview was coded according to the main risk categories and cross-cutting issues identified in the interview guide and in the objectives of Phase 2. The scale used was: 0 = not mentioned; 1 = mentioned as a secondary issue; 2 = mentioned as a relevant issue; 3 = mentioned as a main priority. The resulting figures are exploratory and should be read as structured qualitative evidence rather than as statistical inference. The complete coding tables underlying Figures 25-1 to 29-1 are included in Annex-REGMURCIA_CLIMAAX-Quantitative coding matrices. This annex should be used to understand how the visual outputs were derived from the interview coding and to ensure transparency of the qualitative scoring process.

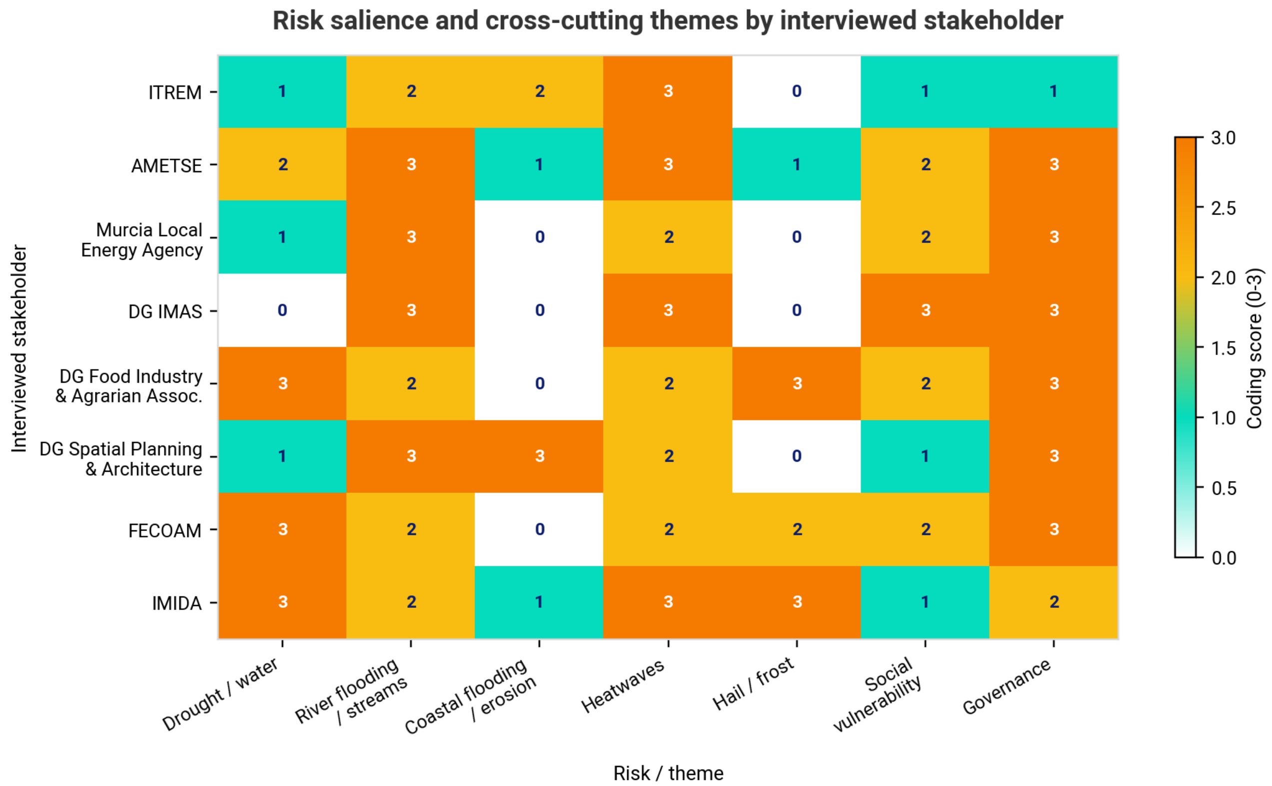

Figure 2-23 Heatmap of risks and cross-cutting themes by interviewed stakeholder. Source: REGMURCIA CLIMAAX interview coding.

Figure 2-23 provides a comparative reading of how the main climate risks and cross-cutting themes emerged across the eight stakeholder interviews. The heatmap should be interpreted as a qualitative coding tool rather than as a statistical measurement: scores reflect the salience of each topic in each interview, from absence or marginal mention to clear identification as a main priority. Its value lies in showing how different institutional and sectoral positions shape the perception of climate risk in the Region of Murcia. The figure confirms a clear sectoral differentiation. Drought and water scarcity are most strongly emphasised by agrarian and agroclimatic stakeholders, particularly DG Food Industry and Agrarian Associations, FECOAM and IMIDA. This reflects the central role of drought in agricultural production, dryland farming, crop yields, insurance, profitability and territorial viability. However, drought is not limited to the agricultural interviews; it also appears, with lower intensity, in other stakeholder perspectives, indicating its broader relevance for the regional risk profile.

River flooding and flooding associated with ephemeral streams show a more transversal pattern. They receive high scores from AMETSE, Murcia Local Energy Agency, DG IMAS and DG Spatial Planning and Architecture, and are also present in agricultural and tourism-related interviews. This suggests that flooding is perceived not only as a hydrological hazard, but also as a territorial, planning, warning and emergency-management issue. The strong salience of this risk among meteorological, municipal, social and spatial-planning actors points to the importance of short response times, local rainfall monitoring, exposed facilities, land-use regulation and accumulated exposure in flood-prone areas.

Heatwaves appear as one of the most consistently relevant risks across stakeholder groups. They are strongly highlighted by ITREM, AMETSE, DG IMAS and IMIDA, and remain relevant in the remaining interviews. This confirms the multi-sectoral nature of extreme heat in the Region of Murcia. Heat is associated not only with public health, but also with social-care facilities, public buildings, outdoor work, tourism, agriculture, energy demand and urban liveability. The interviews therefore support the treatment of heatwaves as a social, functional and territorial risk, rather than as a purely meteorological variable.

By contrast, coastal flooding and erosion and hail/frost appear as more sector-specific risks. Coastal flooding and erosion are especially relevant for ITREM and DG Spatial Planning and Architecture, reflecting their importance for tourism, coastal land use, shoreline management and the Mar Menor. Hail and frost are mainly emphasised by agrarian and agroclimatic actors, particularly DG Food Industry and Agrarian Associations and IMIDA, showing that these hazards are important complementary risks for agricultural damage, insurance and crop adaptation, even if they are not part of the main hazard triad initially selected for the regional assessment.

A particularly important result is the high salience of governance across almost all interviews. This indicates that stakeholders do not perceive climate adaptation as a challenge that can be solved only through better hazard data or more accurate modelling. Coordination between administrations, regulatory clarity, funding mechanisms, staffing capacity, long-term planning and the ability to translate evidence into executable measures are repeatedly identified as decisive conditions for adaptation. In CLIMAAX terms, this finding is especially relevant for the assessment of resilience capacity: the level of risk depends not only on the severity of hazards and exposure, but also on the institutional capacity to anticipate, coordinate, implement and maintain adaptation actions.

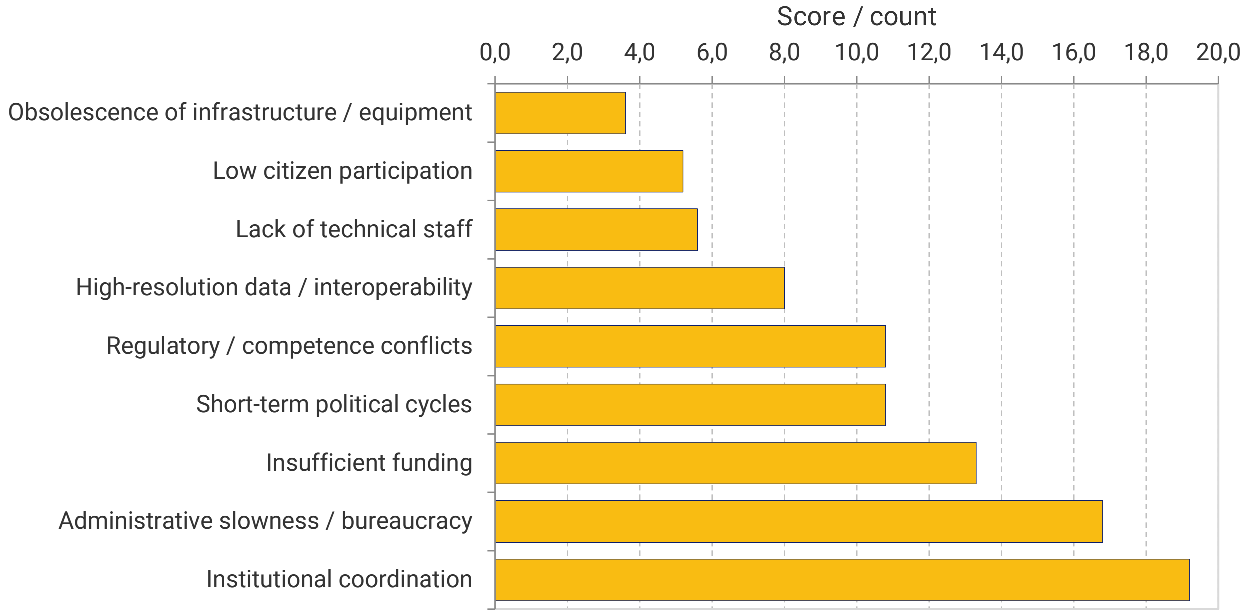

Figure 2-24 Most frequently reported adaptation barriers in the interviews. Source: REGMURCIA CLIMAAX interview coding.

Figure 2-24 shows that the main barriers identified in the interviews are not primarily related to a lack of awareness of climate risks, but to the institutional and operational conditions required to implement adaptation. The highest-scoring barrier is institutional coordination, which appears as a cross-cutting difficulty across several sectors and administrative levels. Stakeholders repeatedly indicate that climate adaptation requires the combined action of regional departments, municipalities, sectoral agencies, water authorities, planning bodies, emergency services, social services and economic sectors. However, these actors often operate through separate procedures, planning instruments and funding channels. This creates fragmentation and makes it difficult to transform climate-risk knowledge into coherent, coordinated and sustained action.

The second major barrier is administrative slowness and bureaucracy. Interviewees do not suggest that technical knowledge is completely absent; rather, they stress that implementation is often delayed by complex procedures, procurement requirements, regulatory uncertainty, limited staff capacity and the difficulty of converting diagnosis into executable projects. This is particularly relevant for measures that require infrastructure works, maintenance of public facilities, adaptation of vulnerable centres, territorial planning updates or the management of European funding. In this sense, the figure shows a clear gap between knowing what needs to be done and being able to implement it within the required timeframe.

Insufficient funding also appears as a major constraint. Adaptation measures often require stable and long-term investment, while available resources may depend on temporary programmes, competitive calls or short funding windows. This is especially problematic for local authorities, social facilities, agricultural adaptation, early-warning systems, data integration and the maintenance or upgrading of exposed infrastructure. The relevance of funding as a barrier suggests that adaptation cannot be treated only as a technical planning exercise; it also requires financial continuity and the capacity to connect risk assessment outputs with investment pipelines.

The figure also highlights the importance of regulatory and competence conflicts and short-term political cycles. These barriers show that adaptation is conditioned by the distribution of responsibilities between institutions and by the time horizon of public decision-making. Climate risks evolve over decades, but many administrative and political decisions are organised around shorter cycles. This can delay preventive measures, weaken continuity between plans and reduce the implementation of actions that may be technically necessary but politically or socially difficult. In territorial planning, flood-prone areas, coastal management, water use, agricultural support and urban adaptation, these conflicts may become decisive.

Other barriers, such as high-resolution data and interoperability, lack of technical staff, low citizen participation and obsolescence of infrastructure or equipment, appear with lower scores but remain important. They indicate that resilience capacity depends on a combination of information, human resources, public engagement and maintenance. Better climate data are useful only if they can be integrated across institutions and translated into operational decisions. Similarly, citizen participation is necessary to increase the social acceptance of adaptation measures, especially where changes in land use, water demand, mobility, building adaptation or coastal management may be required.

Overall, Figure 2-24 is highly relevant for the CLIMAAX assessment because it links stakeholder evidence with the resilience-capacity dimension of climate risk. The interviews suggest that the Region of Murcia does not face adaptation challenges only because hazards are becoming more severe, but also because governance, funding, administrative procedures and implementation capacity may limit the effectiveness of the response. This finding should therefore be considered when interpreting risk priority: a hazard may require urgent action not only because exposure or severity is high, but also because the current institutional capacity to manage it remains insufficient.

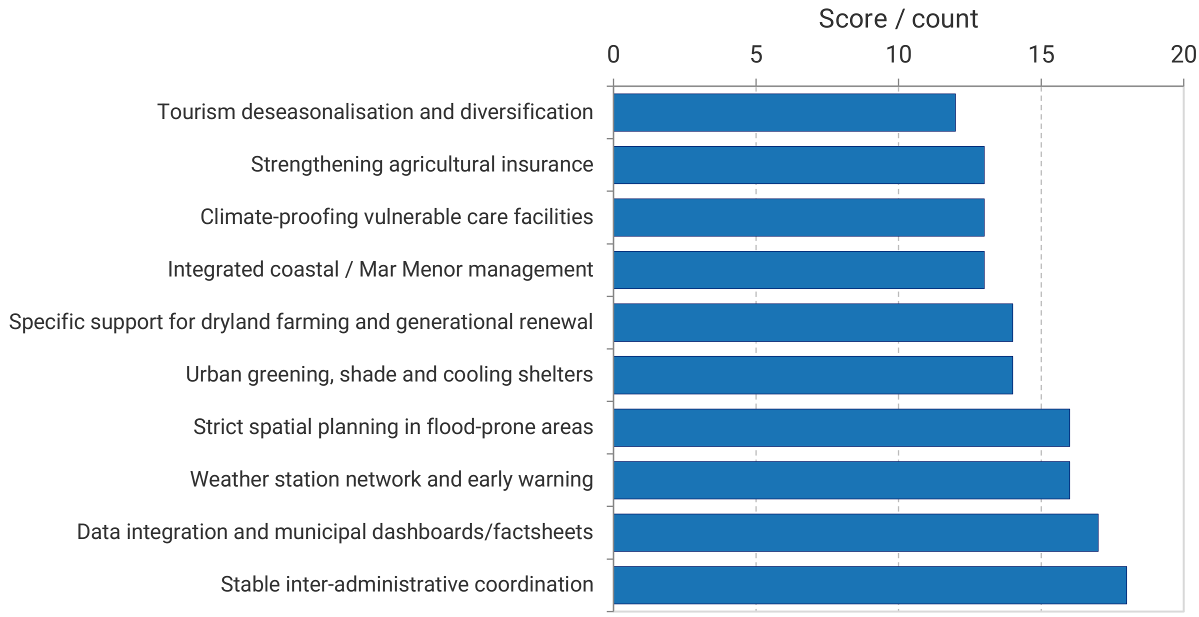

Figure 2-25 Preliminary ranking of adaptation measures emerging from the interviews. Source: REGMURCIA CLIMAAX interview coding.

The ranking of adaptation measures indicates that stakeholders give particular importance to actions that strengthen governance, information systems and implementation capacity. The highest priorities are stable inter-administrative coordination, data integration, municipal dashboards or factsheets, strict spatial planning in flood-prone areas, and improved weather-station and early-warning networks. This suggests that adaptation in the Region of Murcia should not be understood only as a set of physical interventions, but also as an institutional process that requires better coordination, shared information and operational tools for decision-making.

The results also show that sector-specific measures remain important. Support for dryland farming and generational renewal, agricultural insurance, climate-proofing of vulnerable care facilities, integrated coastal and Mar Menor management, urban greening, shade and cooling shelters, and tourism deseasonalisation all appear as relevant adaptation pathways. Overall, the figure points to a balanced adaptation agenda combining governance reform, technical information, territorial planning, social protection, agricultural resilience and sectoral diversification (Figure 2-25).

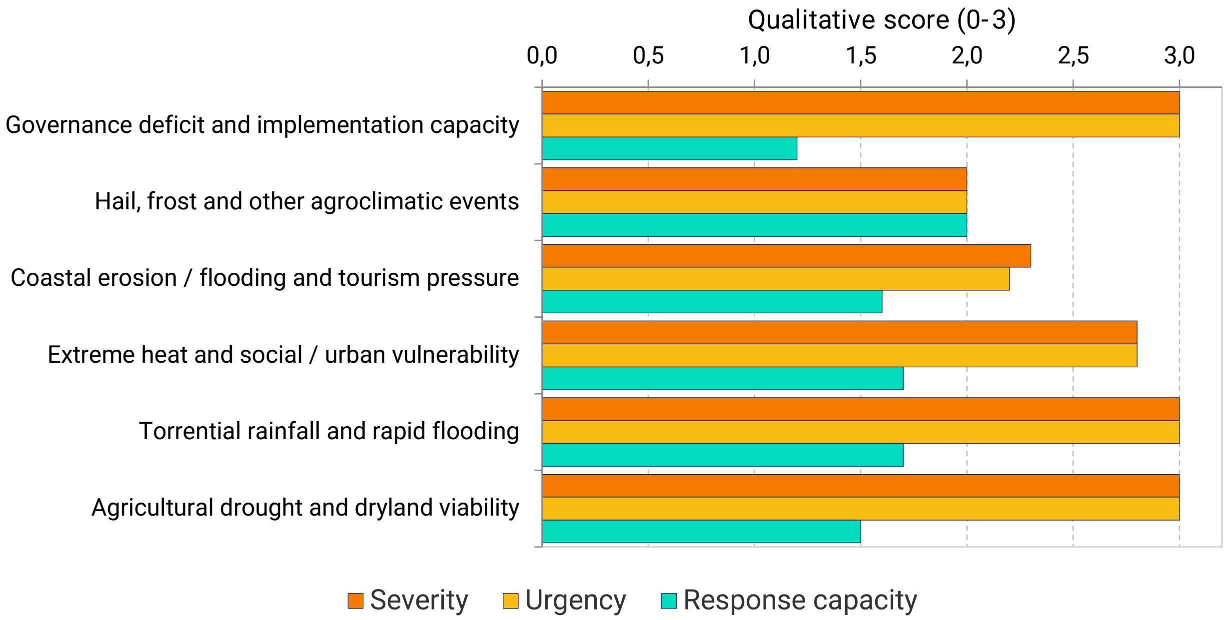

Figure 2-26 Qualitative risk validation by severity, urgency and response capacity. Source: REGMURCIA CLIMAAX interview coding.

Figure 2-26 is particularly relevant because it does not only identify which risks are perceived as important; it also compares perceived severity, urgency and response capacity. This makes it directly useful for the CLIMAAX Key Risk Assessment logic, where priority depends not only on the magnitude of the risk, but also on how immediate it is and whether existing institutions, sectors and territories are able to respond effectively.

The most important pattern is the gap between high severity and urgency on the one hand, and only moderate response capacity on the other. Agricultural drought and dryland viability, torrential rainfall and rapid flooding, extreme heat and social/urban vulnerability, and governance deficit all receive very high scores for severity and urgency. However, response capacity remains clearly lower. This indicates that stakeholders perceive these risks as already pressing, but also as insufficiently addressed by current institutional, financial, technical or operational arrangements.

For agricultural drought and dryland viability, the gap reflects the structural nature of the problem. Stakeholders describe drought not simply as a temporary lack of rainfall, but as a long-term risk affecting production, crop profitability, insurance, dryland farming, livestock, abandonment and erosion. The low-to-moderate response capacity suggests that existing tools may be insufficient to prevent progressive territorial degradation unless they are supported by stable policies, specific support for dryland systems, improved insurance schemes, crop adaptation, water-demand management and long-term rural planning.

For torrential rainfall and rapid flooding, the high severity and urgency scores point to the combination of intense rainfall, ephemeral streams, short warning times and accumulated exposure in flood-prone areas. The response-capacity gap is especially important here because flood risk depends not only on hazard intensity, but also on spatial planning, maintenance, early-warning systems, emergency protocols and the capacity to prevent new exposure. Stakeholders therefore frame flooding as a governance and territorial-planning challenge, not only as a hydrological one.

Extreme heat also shows high severity and urgency, with a moderate response capacity. This confirms the need to treat heatwaves as a social, urban and functional risk. The interviews link heat to vulnerable populations, care homes, public buildings, outdoor workers, schools, tourism, agriculture and urban liveability. The lower response-capacity score suggests that adaptation requires more than general warning systems: it requires climate-proofing of public facilities, shaded and cooled urban spaces, protocols for vulnerable groups, labour protection, building adaptation and better integration between health, social services, urban planning and energy policy.

The governance deficit itself is also scored as highly severe and urgent. This is a key finding. It means that stakeholders do not see governance merely as a background condition, but as a risk amplifier. Fragmented responsibilities, administrative slowness, short-term political cycles, lack of staff, weak coordination and unstable funding can increase climate risk by delaying or weakening adaptation. In this sense, governance capacity becomes part of resilience capacity: even where data and technical knowledge are available, risk remains high if institutions cannot coordinate, finance and implement measures in time.

Coastal erosion/flooding and tourism pressure, and hail/frost and other agroclimatic events, show a slightly different pattern. Their severity and urgency are still relevant, but they appear more sector-specific in the current interview sample. Coastal risk is especially linked to tourism, shoreline management, the Mar Menor and spatial planning, while hail and frost are particularly important for agricultural damage, insurance and crop adaptation. These risks should not be excluded from the assessment, but their interpretation should be linked to the sectors and territories where they are most critical.

Overall, the figure supports one of the main conclusions of the stakeholder consultation: the transition from risk assessment to adaptation planning should focus strongly on implementation capacity. The most urgent risks are not necessarily those for which the region has the strongest response mechanisms. For this reason, the final prioritisation of risks in REGMURCIA CLIMAAX should consider not only exposure and hazard intensity, but also institutional readiness, operational capacity, funding continuity, territorial planning instruments and the ability to protect vulnerable groups. This evidence will be especially useful when the interview findings are later compared with the modelled workflow results.

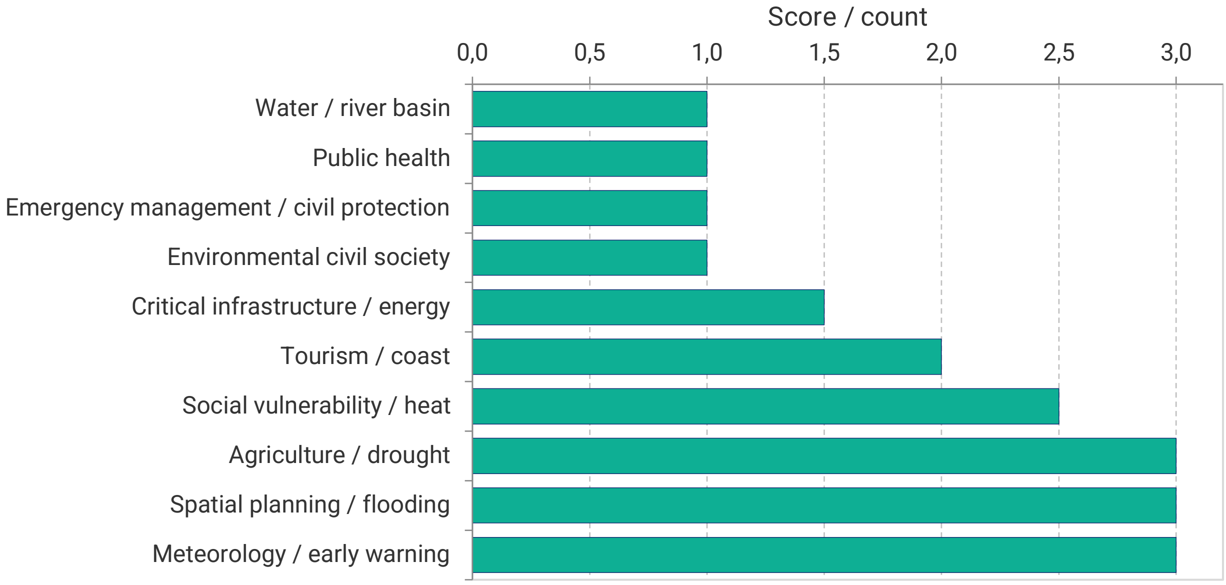

Figure 2-27 Thematic coverage of interviews and remaining gaps. Source: REGMURCIA CLIMAAX interview coding.

Figure 2-27 is useful for interpreting the scope and limitations of the interview evidence. The strongest coverage is found in agriculture/drought, spatial planning/flooding and meteorology/early warning. This is consistent with the composition of the interview sample and means that the qualitative evidence is particularly robust for understanding drought impacts on agriculture, territorial exposure to flooding, and the role of local meteorological information in preparedness.

The figure also shows medium coverage for social vulnerability/heat and tourism/coast. These areas are sufficiently represented to provide relevant insights, especially regarding care facilities, public buildings, vulnerable populations, tourism diversification and coastal pressure, but they may require further validation in later stages.

Lower coverage appears for water and river-basin management, public health, emergency management/civil protection, critical infrastructure/energy and environmental civil society. These should not be interpreted as irrelevant topics; rather, they indicate areas where the current interview sample provides less direct evidence. This is important for the D2 because it helps define the limits of the qualitative analysis and identifies priorities for future stakeholder engagement, especially when the modelled workflow results are available and additional validation is required (Figure 2-27).

Recurring ideas, measures and issues requiring explicit mention

Beyond the interview-by-interview synthesis and the coded figures, several ideas, measures and concerns appear repeatedly across interviews. They should be explicitly mentioned because they connect stakeholder knowledge with the practical use of CLIMAAX results and with the future design of adaptation measures (Table 2-15).

Table 2-15 Recurrent ideas, measures and issues emerging across the interviews.

Recurring idea / measure	*Mentions*	*Interpretation*
Integrated and stable inter-administrative coordination	8	Almost all interviews frame adaptation as dependent on coordination across regional, local, basin, sectoral and technical bodies.
Administrative capacity and implementation gap	8	Stakeholders repeatedly stress that knowledge exists, but projects are slowed by procedures, procurement, staffing and political cycles.
Data integration, dashboards and usable local outputs	6	Several actors request operational maps, factsheets, dashboards or interoperable datasets that can be used in planning and management.
Early warning and proximity meteorological networks	5	Local rain, heat and agroclimatic monitoring is seen as decisive for rapid events and agricultural decision-making.
Strict spatial planning in flood-prone areas	5	Flood adaptation is repeatedly linked to land occupation, planning rules, use restrictions and prevention of future exposure.
Dryland farming as a territorial, not only productive, issue	4	Dryland agriculture is connected to income, abandonment, erosion, landscape, insurance, livestock and generational renewal.
Climate-proofing vulnerable social and public facilities	3	Heat risk is translated into concrete needs in care homes, schools, social centres and public buildings.
Agricultural insurance and economic stability	3	Insurance affordability and coverage appear as stabilising tools for drought, hail, frost and production shocks.
Urban cooling, shade and green infrastructure	3	Heat adaptation is linked to trees, shade, cooling shelters, buildings, thermal comfort and outdoor work.
Tourism deseasonalisation and territorial diversification	2	Tourism risk is not expressed as immediate collapse, but as a need to diversify products, seasons and destinations.
Integrated coastal and Mar Menor management	2	Coastal risk appears as a governance and planning challenge where tourism, coastline, ecosystems and development intersect.

The most important repeated message is that adaptation requires stable coordination mechanisms. This theme appears as a precondition for the usefulness of all other measures: flood planning, water management, agricultural adaptation, social vulnerability protection, coastal management, municipal implementation and the use of climate-risk information.

A second repeated idea is the implementation gap. Stakeholders do not generally argue that the Region lacks all knowledge or all technical capacity. Instead, they identify slow procedures, insufficient staff, fragmented competences, funding constraints and short political cycles as the main obstacles to action. This distinction is crucial for Phase 3 because adaptation measures must be designed with realistic institutional pathways.

A third group of repeated issues concerns the need to make climate information operational. Stakeholders value detailed maps, municipal factsheets, dashboards, viewers, downloadable data and usable indicators. CLIMAAX outputs will be more useful if they are translated into planning instruments, investment criteria, maintenance priorities and practical information for municipalities and sectors.

Finally, the interviews repeatedly connect risk with social and territorial vulnerability: dryland farming is linked to abandonment and generational renewal; heatwaves are linked to care facilities and public buildings; flood risk is linked to planning and accumulated exposure; and coastal risk is linked to tourism, territorial pressure and the Mar Menor. These connections should be preserved in the because they prevent an overly narrow interpretation of hazards as purely physical phenomena.

Integration into the CLIMAAX workflows

This section provides a preliminary thematic alignment between the interview evidence and the analytical workflows selected for REGMURCIA CLIMAAX. It should not be interpreted as a final validation of the modelled workflow outputs, since the full regionalized results will be assessed separately. Rather, the table identifies how stakeholder knowledge can support the interpretation of each workflow by adding sectoral, territorial, institutional and functional dimensions that are not always fully captured by hazard indicators alone (Table 2-16).

For the drought workflow, the interviews show that drought risk should be interpreted beyond average yield losses or generic water-deficit indicators. Stakeholders repeatedly link drought to productive dryland systems, crop losses, phenological changes, agricultural insurance, abandonment, erosion, generational renewal and extensive livestock. This broadens the interpretation of drought as a socioeconomic and territorial risk, especially in areas where irrigation is limited or adaptive margins are lower.

For the flood workflow, the interviews stress the importance of connecting flood-risk mapping with territorial planning, municipal responsibilities, ephemeral streams, small catchments, early-warning capacity and the functional vulnerability of exposed assets. Stakeholders indicate that flood exposure should not be read only through inundation footprints, but also through land use, building characteristics, warning time, critical infrastructure, public facilities and the capacity to prevent new exposure.

For the heatwave workflow, the interviews reinforce the need to include social and functional vulnerability. Extreme heat is linked to care homes, occupational centres, schools, public buildings, air-conditioning systems, older people, people with disabilities, outdoor workers, tropical nights, urban heat islands, shade, tree cover and energy poverty. This suggests that heat risk should be interpreted as a social, infrastructural and institutional risk, not only as a temperature anomaly.

Finally, the coastal and tourism risk evidence points to erosion, summer pressure, second homes, accommodation adaptation, deseasonalisation, territorial diversification, blue tourism and Mar Menor-related issues. Although this evidence is less extensive than for agriculture, flooding or heat, it confirms that coastal risk remains relevant for the regional climate-risk system, particularly where tourism development, coastal protection and territorial sustainability interact.

Table 2-16 Integration of interview evidence into the CLIMAAX analytical workflows.

Workflow / risk area	*Stakeholder contribution to interpretation*
Drought workflow	The interviews confirm that drought risk extends beyond average yield losses. Stakeholders refer to productive dryland systems, crop losses, yield decline, phenological changes, insurance, abandonment, erosion, generational renewal and extensive livestock dependent on straw and fodder. Drought is therefore a socioeconomic and territorial risk, not only a water-deficit indicator.

Flood workflow	Interview evidence links flood-risk mapping with SNCZI/CHS, municipal planning, coastal and territorial guidelines, ephemeral streams and small catchments, Campo de Cartagena and Los Alcazares, metropolitan Murcia, building floor level, functional vulnerability, critical infrastructure and early-warning networks. Flood exposure should be interpreted by use, floor level, warning time and service criticality, not only by inundation footprint.
Heatwave workflow	The interviews reinforce the need to integrate social and functional variables: care homes, occupational centres, schools, condition and redundancy of air-conditioning systems, older people, people with disabilities, outdoor workers, tropical nights, urban heat islands, shade, tree cover, public buildings and energy poverty. Heatwaves are therefore a social, infrastructural and institutional risk.
Coastal and tourism risk	The coastal and tourism evidence includes erosion, summer pressure, second homes, blue tourism, adaptation of accommodation, deseasonalisation, territorial diversification, Mar Menor-related issues and compatibility between tourism development and territorial protection. The evidence is less extensive than for agriculture or river flooding, but it identifies coastal risk as a relevant component of the regional climate-risk system.

Preliminary implications for risk prioritisation

This table presents a preliminary stakeholder-based prioritisation derived from the interview evidence. It should be understood as a qualitative validation layer, not as the final prioritisation of the Climate Risk Assessment. Its purpose is to show which risks appear most consistently and most strongly across the interviews, and how stakeholders justify their relevance from sectoral, territorial and institutional perspectives.

The three risks classified as very high are agricultural drought and dryland viability, torrential rainfall and rapid flooding, and extreme heat with social and urban vulnerability. This confirms that the interview evidence broadly supports the main hazard areas selected in REGMURCIA CLIMAAX, while also refining their interpretation. Drought is framed as a structural agricultural and territorial risk, linked to production losses, income, insurance, abandonment, erosion and extensive livestock. Flooding is interpreted as a rapid-onset territorial and governance risk, shaped by torrential rainfall, ephemeral streams, exposed areas, planning decisions and warning capacity. Heat is presented as a multi-sectoral risk affecting health, buildings, work, tourism, agriculture and vulnerable groups.

The table also identifies two risks that require specific attention. Coastal erosion, coastal flooding and tourism pressure are classified as high, because they appear less widely across the interviews but are highly relevant for tourism, coastal planning, the Mar Menor and exposed coastal areas. Hail, frost and other agroclimatic events are classified as high-sectoral, as they are especially important for agriculture and insurance, even though they are not part of the main hazard triad. Finally, governance deficit and implementation capacity are included as a cross-cutting priority, because they influence whether adaptation measures can move from diagnosis to action. This is particularly important for CLIMAAX, since governance and response capacity may increase or reduce actual risk even where hazard exposure is similar.

Overall, the prioritisation helps translate the interview findings into inputs for the later risk assessment stage. It indicates where stakeholder concern is strongest, which risks may require additional interpretation beyond modelled outputs, and which institutional or implementation factors should be considered when assessing severity, urgency and resilience capacity. final risk prioritisation should still be completed once the regionalized modelling results are available and compared with the survey and interview evidence (Table 2-17).

Table 2-17 Preliminary risk prioritisation derived from the interview evidence.

Qualitative priority	*Risk*	*Justification from interviews*
Very high	Agricultural drought and dryland viability	Reinforced by DG Food Industry, FECOAM and IMIDA; affects production, income, insurance, abandonment, erosion and livestock.
Very high	Torrential rainfall and rapid flooding	Reinforced by AMETSE, Spatial Planning, IMAS, Local Agency and ITREM; strong exposure and governance component.
Very high	Extreme heat and social / urban vulnerability	Reinforced by AMETSE, IMAS, IMIDA, ITREM and Local Agency; affects health, buildings, work, tourism and crops.
High	Coastal risk: erosion, coastal flooding and tourism pressure	Appears in ITREM and Spatial Planning; relevant for tourism, coastline, Mar Menor and coastal planning.
High-sectoral	Hail, frost and agroclimatic events outside usual patterns	Highly relevant for agriculture and insurance; complements the main hazard triad.
Cross-cutting	Governance deficit and implementation capacity	Appears in almost all interviews; determines whether measures move from diagnosis to action.

2.2 Risk Exploration

Risk exploration is the broad screening of hazards, exposures and vulnerabilities that are most relevant to stakeholders and to the wider public. For REGMURCIA, this screening was first carried out in Phase 1, where the four climate hazards considered most relevant to the CARM – river flooding, coastal flooding, agricultural drought, and heatwaves – were identified and justified, and a future scenario approach was chosen. This section revisits both steps and reports what has, and has not, changed during Phase 2. Consistent with the decision to deepen the hazards for which suitable regional, national or local data were available, the hazard screening itself is unchanged from D1; what has changed is the depth of evidence behind the hazards, detailed in Section 2.3.

2.2.1 Screen risks (selection of main hazards)

Changes from Phase 1. River flooding, coastal flooding, agricultural drought and heatwaves remain the four hazards judged most relevant for the CARM, for the reasons set out in Phase 1 – high historical impact, increasing exposure from urbanisation, tourism and agricultural pressure, and the strategic importance of the affected sectors. Phase 2 modifies the depth and quality of evidence behind these hazards. Agricultural drought, river flooding and coastal flooding are substantially deepened using higher-resolution regional, national or local data. Agricultural drought is updated through a revised workflow based on regional crop, production, surface and rainfed-exposure data, resulting in a more coherent assessment of expected losses for rainfed agriculture (Section 2.3.1). River flooding is deepened through a comparative analysis of European and Spanish national hazard and exposure datasets, while coastal flooding is deepened through a dedicated high-resolution sea-level-rise and damage model (Section 2.3.2). Heatwave risk is not quantitatively re-run in this phase because the Phase 1 workflow did not show the same level of inconsistency detected for flood and drought, but its risk interpretation is strengthened through stakeholder evidence (Sections 2.3.3 and 2.4.7).

Climate hazards relevant for the CARM. Table 2-18 lists the four hazards prioritised in Phase 1, the rationale recorded there, and the status of the evidence base for each in Phase 2. Note that wildfires are interconnected with drought and heat (D1 notes amplification) but not separately assessed

Table 2-18 Climate hazards relevant for the CARM: Phase 1 rationale and Phase 2 status

Hazard	*Rationale (Phase 1)*	*Phase 2 update*	*Selected for CRA*
River flooding	High historical impact; Segura basin flash floods; urban exposure in the Murcia metropolitan area, Lorca and Campo de Cartagena	Deepened – JRC vs CNIG hazard-map comparison (Section 2.3.2)	Yes
Coastal flooding	Acute exposure along the 274 km littoral; 32% of the regional population; tourism and petro-industrial assets	Deepened – new bathtub-with-hydraulic-connectivity hazard modelling on the 5 m IGN/PNOA MDT05 DEM, run continuously across the 0-100 cm SLR range, with a validated vulnerability function and municipality-level damage estimates	Yes
Agricultural drought	46% of cultivated land irrigated; Segura basin aquifer overexploitation	New FAO-56 crop-water-demand parameterisation, ESAM production/price records and a SIGPAC/CREM spatial exposure layer	Yes
Heatwave	Urban heat island; elderly, outdoor-worker and low-income exposure	No comparable quantitative re-run; Phase 1 outputs retained because no major inconsistency comparable to the flood and drought workflows was identified, and interpreted with stakeholder evidence.	Yes

Current situation. The current-situation evidence gathered in Phase 1 for all four hazards – including the 2019 DANA (7 fatalities, €1.3 billion in damages), Segura basin flash-flood hotspots, the Mar Menor coastal-tourism exposure, agricultural drought impacts on irrigated crops, and the urban heat island in Murcia and Cartagena – is recapped in Section 2.1.2 and is not repeated here. What is new in Phase 2 is a quantified, source-by-source estimate economic damage, presented in Section 2.3.2.

Hazards selected for Phase 2 deepening. Per the decision to work only with the data already available for this deliverable, river and coastal flood economic risk received a full quantitative deepening culminating in revised loss estimates (Section 2.3.2). Agricultural drought received an updated quantitative workflow based on crop-specific parameters, regional production and price records, official crop-surface data and spatially explicit rainfed agricultural exposure, producing a more coherent expected-loss assessment for rainfed agriculture (Section 2.3.1). Heatwave risk retains the Phase 1 quantitative findings (Section 2.3.3), because this workflow did not show the same level of inconsistency identified for flood and drought. Phase 2 nevertheless strengthens its interpretation through stakeholder evidence, while further local quantitative refinement remains an objective for a future phase.

Data availability. Table 2-19 contrasts the data used in D1 with the new data integrated in Phase 2 and the gaps that remain, by hazard.

Table 2-19 Data used in D1 and new data integrated in Phase 2, by hazard

Hazard	*Data used in D1 (Phase 1)*	*New data integrated in Phase 2*	*Remaining gaps*
River & coastal floods	JRC European flood hazard maps (10/100/500-yr return periods); LUISA land use; GTSMv3.0 coastal water levels; SNCZI national flood mapping (used for comparison)	River floods: CNIG national flood hazard maps; SIOSE national land use; Huizinga et al. (2017) depth-damage curves via the DamageScanner library; harmonisation to 50 m, clipped to the CARM boundary. Coastal floods: custom bathtub-with-hydraulic-connectivity model (University of Murcia) on the 5 m IGN/PNOA MDT05 DEM, run continuously across the 0–100 cm SLR range; hyperbolic-tangent vulnerability function validated against the September 2019 Los Alcázares flood; municipality-level damage estimates for all eight affected coastal municipalities	River floods: no new hydraulic modelling (CNIG/SNCZI maps used as-is); depth-damage curves remain international (Huizinga et al.), not locally calibrated; no validated post-event high-water-mark survey. Coastal floods: the new bathtub model and validated vulnerability function close the modelling and calibration gaps identified for Phase 1, but D1 reports no coastal euro-damage baseline for benchmarking
Agricultural drought	CORDEX regional climate models; MapSPAM/FAO-IIASA GAEZ crop exposure; GAEZ irrigation distribution	FAO-56 dual crop-coefficient parameters (Kc, Ky, growth-stage lengths) for seven dryland crops, replacing Phase 1's single Doorenbos-Kassam K_i factor (three crops); ESAM crop production/price records (2012–2024) and SIGPAC 2026/CREM-ECONET spatial distribution, replacing Phase 1's global MapSPAM/GAEZ exposure layer	Remaining gaps include local calibration of crop-specific vulnerability parameters, validation against observed drought-loss events, incorporation of additional or updated regional climate projections in future iterations, extension to irrigated crops and indirect economic impacts, and further stakeholder validation of the resulting loss estimates.
Heatwave	AEMET temperature records; 2020 population-density rasters (75–79, ≥80 age bands); stationary age-structure assumption	No comparable quantitative re-run; Phase 1 outputs retained and interpreted with stakeholder evidence.	Further local validation of social and demographic vulnerability, integration of updated demographic projections, urban heat-island evidence, public-health data and facility-level exposure information.

Net effect on the screening step. Phase 2 does not revisit the prioritisation criteria applied in Phase 1; it sharpens the evidentiary basis for three of the four hazards already selected — agricultural drought, river flooding and coastal flooding — while retaining the Phase 1 quantitative baseline for heatwaves and strengthening its interpretation through stakeholder evidence. The implications of comparing JRC against CNIG (and LUISA against SIOSE) for river and coastal flood damage estimates – including the magnitude of the resulting discrepancy with Phase 1's own figures – are analysed in Section 2.3.2. For agricultural drought, the new FAO-56 vulnerability parameters and ESAM/SIGPAC-CREM exposure data sharpen the evidentiary basis for the vulnerability and exposure layers.

2.2.2 Choose Scenario

Changes from Phase 1. The scenario framework defined in Phase 1 is unchanged in Phase 2: scenarios combine a future climate condition with a future socio-economic condition over a defined time horizon, hazard by hazard. Phase 2 does not introduce new climate scenarios. For river floods, the deepening reported in Section 2.3.2 re-estimates damage under the same baseline conditions used in D1, now also drawing on Spanish national (CNIG/SIOSE) data, so that scenario assumptions are held constant and the comparison isolates the effect of the hazard- and exposure-data source. For coastal floods, Phase 2 replaces Phase 1's discrete return-period approach with a continuous sea-level-rise model swept from 0 to 100 cm, annotated with the same RCP4.5/RCP8.5 2050/2100 markers used in D1 rather than new scenarios; this is a change in hazard-modelling resolution, not in the underlying climate scenario framework.

Future climate conditions. As established in Phase 1, REGMURCIA uses hazard-specific RCP scenarios: agricultural drought is assessed under RCP2.6 and RCP8.5 using CORDEX regional climate models; river and coastal floods use RCP4.5 and RCP8.5; heatwaves use RCP4.5 and RCP8.5. Phase 1 derived coastal water levels from GTSMv3.0; Phase 2 replaces this with a continuous sea-level-rise sweep (Section 2.3.2), retaining the same RCP4.5/RCP8.5 2050/2100 markers for comparability. The RCP scenario framework itself is unchanged in Phase 2. The river flood deepening in Section 2.3.2 is a comparison of hazard and exposure data sources under the same baseline conditions, not a re-run under new climate scenarios; the coastal flood deepening additionally introduces a new continuous hazard-modelling approach, described in Section 2.3.2.

Future socio-economic developments. Phase 1 combined these climate scenarios with the socio-economic exposure layers available at the time: LUISA land use for floods, and GAEZ/MapSPAM crop and irrigation distributions for drought. For heatwave vulnerability, Phase 1 used 2020 population-density rasters by age band held stationary across the projection horizons – a simplification D1 itself flagged as a limitation, pending INE/Eurostat demographic projections. This assumption is unchanged in Phase 2; the new flood damage estimates in Section 2.3.2 likewise use a single exposure snapshot (LUISA or, newly, SIOSE) rather than a projected future land-use scenario.

Combination approach. Each hazard combines its climate condition and exposure layer at a given time horizon to produce an impact estimate – for example, flood extent × land use × a depth-damage function for floods. This combination logic is unchanged in Phase 2. What is new is that, for floods, the same logic is now run with four data permutations – JRC or CNIG hazard maps, paired with LUISA or SIOSE land use – so that the resulting damage estimates can be compared directly (Section 2.3.2).

Time horizons. Phase 1 used near-future (2031–2050/2031–2060) and far-future (2071–2100) horizons for drought; a 2018 baseline plus a 2050 projection for coastal flooding; and near- and far-future horizons referenced to a 1986–2015 baseline (far future approximately 2066–2095) for heatwaves. The river flood hazard maps (JRC and CNIG) represent current/baseline conditions rather than a projected future horizon. These time horizons are unchanged in Phase 2; the Section 2.3.2 comparison is a baseline-period comparison of data sources, not a comparison across time horizons.

2.3 Regionalized Risk Analysis

Fine-tuning approach. For agricultural drought (Workflow #1, Section 2.3.1), Phase 2 updates the workflow by replacing Phase 1's generic vulnerability and exposure inputs with regional crop-specific parameters, official production and price records, official crop-surface data and a spatially explicit rainfed exposure layer derived from SIGPAC and CREM/ECONET. This allows the assessment to produce revised and more coherent expected-loss estimates for rainfed agriculture, overcoming several of the inconsistencies identified in Phase 1. For river and coastal floods (Workflow #2, Section 2.3.2), a dedicated Phase 2 analysis, completed at the University of Murcia (UMU), independently re-computed flood hazard extent and economic damage for the CARM using both the European sources applied in Phase 1 (JRC hazard maps, LUISA land use) and Spain's official national sources (CNIG flood hazard maps, SIOSE land use), providing a like-for-like comparison of the CLIMAAX Toolbox's European default pipeline against high-resolution national data for the same hazard, region and return periods; this is the basis for the fine-tuning presented in Section 2.3.2. Heatwaves (Workflow #3, Section 2.3.3) are retained from Phase 1 as the quantitative baseline because this workflow did not show the same level of internal inconsistency or data-source divergence identified for flood and drought. Phase 2 therefore does not perform a comparable quantitative re-run, but strengthens the interpretation of heatwave risk through stakeholder evidence; further local quantitative refinement remains an objective for Phase 3.

Data used. Agricultural drought (Workflow #1) — Vulnerability: FAO-56 crop-water/yield-response parameters (initial/mid/late-season crop coefficients, root-depth fractions, growth-stage length fractions, yield-response factor) for seven CARM rainfed crops (barley, oats, wheat, olive, almond, wine grape, pistachio), replacing Phase 1's single, generic Doorenbos and Kassam (1979) K_i factor covering only three crops. Exposure: crop production (t) and field price (€/t) from the Region of Murcia's official agricultural-statistics portal (ESAM), historical average 2012–2023/24 for production and weighted average 2020–2024 for price, spatially distributed using SIGPAC 2026 rainfed (irrigation coefficient = 0) parcels weighted proportionally by CREM/ECONET municipal crop-area statistics, replacing Phase 1's global MapSPAM/GAEZ exposure layer.

River and coastal floods (Workflow #2) — Hazard: JRC European river-flood depth maps for RP10/100/500 (D1 baseline, ~90 m native resolution) and CNIG national flood hazard maps for the same return periods (1 m native resolution). Exposure: LUISA/Copernicus land use (D1 baseline, ~100 m) and SIOSE, the Spanish national land-use cadastre. Vulnerability: Huizinga et al. (2017) depth–damage curves, applied through the open-source DamageScanner library — an independent, peer-reviewed alternative to the JRC-derived, country-adjusted curves used natively by the CLIMAAX Toolbox in D1. All hazard and exposure layers were homogenized to a common 50 m grid, reprojected to EPSG:25830, and clipped to the CARM administrative boundary (11,316 km²) to ensure comparability across sources.

New impact metrics. Phase 2 adds a hazard×exposure attribution matrix — JRC+SIOSE, JRC+LUISA, CNIG+SIOSE, CNIG+LUISA — computed for each of the three return periods, allowing the aggregate damage estimate to be decomposed into the share attributable to the hazard-map source versus the land-use source. This was not possible under Phase 1's single-pipeline CLIMAAX Toolbox output and is the central new analytical contribution of this phase (Section 2.3.2.2).

Indirect impacts. No. As in Phase 1, the analysis is limited to direct economic damage to the building and land-use asset stock implied by the depth–damage functions. Indirect impacts (business interruption, supply-chain disruption, loss of agricultural income beyond the damaged parcel) remain out of scope.

Datasets and limitations. Three further limitations apply to the drought deepening: (i) the FAO-56 crop parameters (Kc, Ky, growth-stage lengths) are generic literature values not locally calibrated to Murcia-specific cultivars, soils or irrigation practices; (ii) the SIGPAC/CREM-ECONET spatial distribution is, by the source methodology's own characterization, a "potential compatible surface" rather than an exact parcel-level cartography of crops; (iii) for tractability, all dried-fruit/nut crops were modelled as almond and mixed-crop parcels (under 1% of production) were excluded, which may understate losses for pistachio and other minor nut crops. Analogously, three limitations apply to the flood deepening: (i) the Huizinga et al. (2017) curves derive from international case studies and are not calibrated to the specific construction and economic characteristics of the CARM; (ii) reclassifying SIOSE categories to the LUISA nomenclature to enable comparison introduces additional uncertainty in the exposure layer; (iii) homogenizing all layers to a common 50 m grid — necessary for comparability — discards spatial detail that could affect locally estimated damages, particularly relative to CNIG's native 1 m resolution.

2.3.1 Workflow #1: Agricultural droughts

Table 2-20 Data overview workflow #1

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
CORDEX regional climate projections (daily precipitation, Tmax/Tmin, relative humidity, solar radiation, wind speed), combined with soil available-water capacity, elevation and thermal climate zone; RCP2.6/RCP8.5. D1 gives two slightly different sets of assessment periods across its table (2031–2060/2071–2100) and text (near future 2031–2050/far future 2071–2100) (D1, Table 2-6, §2.3.1.1). Not updated in Phase 2.	Distribution of fully-irrigated cropland (2010, GAEZ) as sensitivity proxy, combined with per-crop yield-response (K_i) factors from Doorenbos and Kassam (1979) — a single-value, non-spatial factor D1 itself flags as outdated and ill-suited to Murcian crops, pending replacement with Steduto et al. (2012) and IMIDA-calibrated curves (D1, §1.3, Table 2-7).	Global crop production (42 crops, 2020, MapSPAM) and aggregated crop value (FAO–IIASA GAEZ). Phase 1's own Table 2-3 benchmarks these against official statistics and finds substantial divergence (almond under-represented ≈4×, olive over-represented >4×, citrus area reduced to a near-negligible 33 ha vs. an actual 40,135 ha), which D1 says "result[s] in a poor CRA for drought in the CARM."	Lost-opportunity cost and irrigated-area share by grid cell, for olive, almond and barley. Phase 1's own figures are internally inconsistent: §2.3.1.2 reports olive losses "totaling approximately €30,000" and barley losses "over €10 million," while its Conclusions give olive losses "up to €16 million" and barley losses "below €1 million." Almond losses could not be costed (no production-data series found). Phase 2 reports the discrepancy rather than selecting one figure.
The CORDEX-based hazard layer described above is carried forward unchanged from D1.	FAO-56 dual crop-coefficient parameters (Kc-ini, Kc-mid, Kc-end), root-development fractions (RD1, RD2), depletion fraction (DF), four-stage length-of-growing-period fractions (LGP-f1 through LGP-f4) and yield-response factor (Ky) 2-21 for seven rainfed (dryland) crops: barley, oats, wheat, olive, almond, wine grape and pistachio. Replaces Phase 1's single, non-spatial Doorenbos and Kassam (1979) K_i factor, which covered only three crops and which D1 itself flagged as outdated (D1, §1.3, Table 2-7).	Crop production (t, 2012–2023/24 historical average) and field price (€/t, 2020–2024 weighted average) for the same seven crops, from the Region of Murcia's official agricultural-statistics portal (ESAM; Table 2-22), spatially distributed using SIGPAC 2026 rainfed (irrigation coefficient = 0) parcels weighted proportionally by CREM/ECONET municipal crop-area statistics (Table 2-23), illustrated in Figure 2-31. Replaces Phase 1's global MapSPAM (42-crop, 2020)/FAO–IIASA GAEZ exposure layer, which Phase 1's own Table 2-3	Revised expected-loss estimates for rainfed agriculture based on the updated Phase 2 workflow. The outputs are derived from crop-specific FAO-56 parameters, official production and price records, and SIGPAC/CREM spatial exposure for the main rainfed crops analysed. These results replace the inconsistent Phase 1 drought-loss estimates and provide a more coherent basis for agricultural and territorial adaptation planning.

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
		found to diverge substantially from official statistics.	

2.3.1.1 Hazard assessment

Phase 2 retains the climate-hazard layer used in Phase 1 for agricultural drought, but updates the risk workflow by replacing the exposure, vulnerability and economic-value inputs with regional data. The hazard component therefore remains based on the CORDEX projections used in D1, while the impact assessment is substantially improved through the updated regional crop and rainfed-exposure evidence described below. Phase 1's drought hazard assessment is built on CORDEX regional climate projections (daily precipitation, temperature, relative humidity, solar radiation, wind speed) under RCP2.6 and RCP8.5, combined with soil water-holding capacity and elevation (D1, Table 2-6). Of the three crops assessed — olive, almond and barley — olive is consistently identified as the most affected and barley as the least, though Phase 1's own headline figure for olive yield loss under the far-future RCP8.5 scenario varies across its sections: 42.4% in the hazard-assessment text (D1, §2.3.1.1), "up to 60%" in its Executive Summary, and 45.4% in its Conclusions. This internal inconsistency is reported here as found in D1, rather than resolved by selecting one figure. D1 situates these projections against an already-stressed water system — Segura basin reservoirs at 17% of capacity in September 2024 and 28.7% in late July 2025 — and projects the cumulative dry-spell duration to lengthen by 5–10 days/year under SSP2-4.5 or 12–18 days/year under SSP5-8.5 by 2041–2070.

Phase 2 complements this hazard assessment with a multi-model trend analysis using four GCM-RCM combinations under the RCP2.6 and RCP8.5 scenarios — selected as the most extreme available, to bound the full range of uncertainty — for the reference (2006–2020), near-future (2041–2060) and far-future (2081–2100) periods. Figure 2-28 shows the resulting evolution of maximum temperature averaged over the Región de Murcia for the selected models and scenarios; trends are broadly consistent across models within a given scenario, and under RCP8.5 the end-of-century change relative to the reference period reaches approximately 4°C. Figure 2-29 shows the corresponding precipitation trends, which are less clear-cut: a decline prevails, but its magnitude depends on both the scenario and the individual model, precipitation shows substantial temporal variability, and depending on the period considered it can even increase. Figure 2-30 illustrates a case in which precipitation declines by around 40% relative to the reference period. This matters because, although the computed water deficit depends on temperature, precipitation remains the dominant driver.

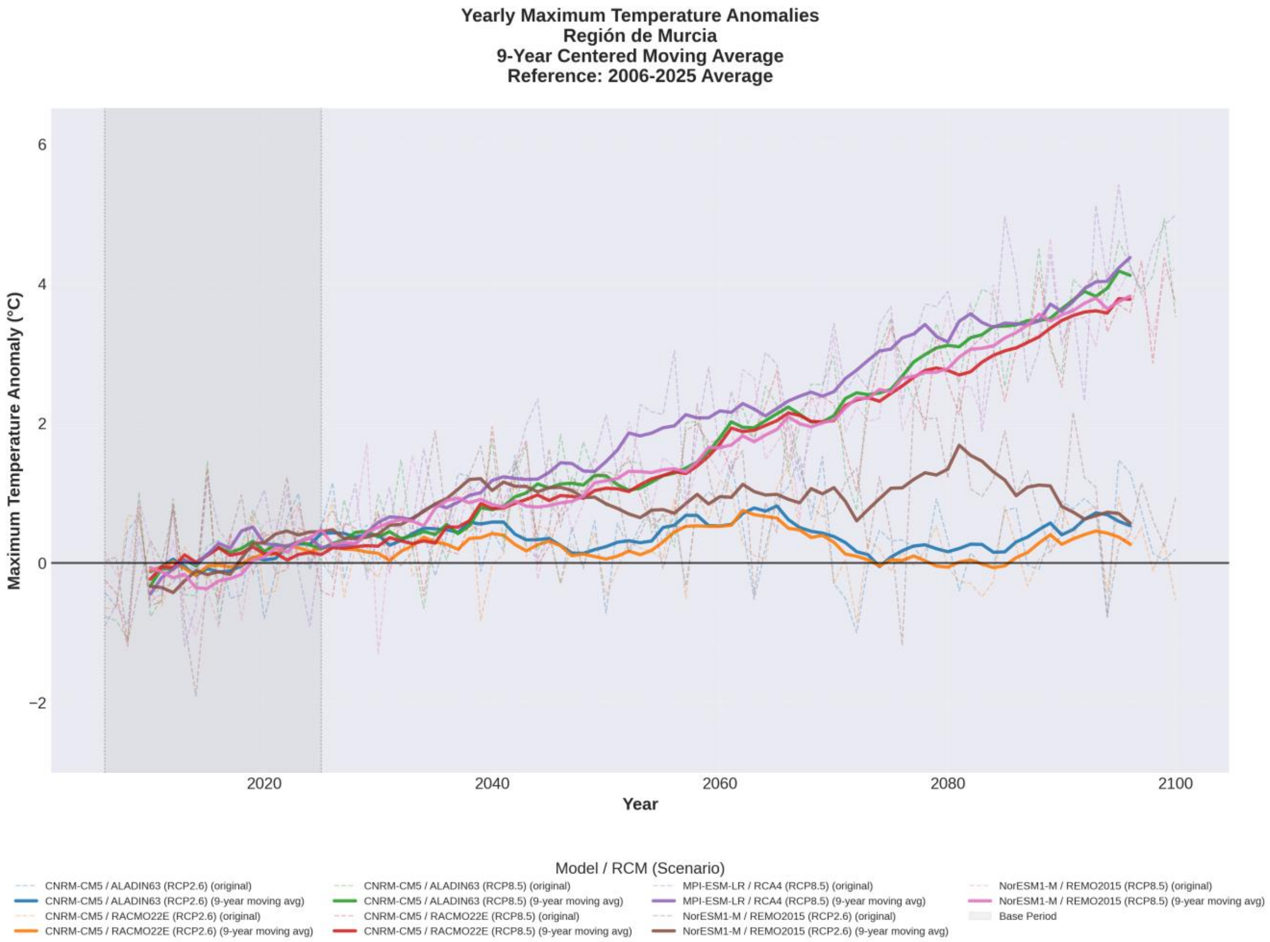

Figure 2-28 Evolution of maximum temperature averaged over the Región de Murcia for 4 GCM-RCM model combinations under RCP2.6 and RCP8.5, reference (2006–2020), near-future (2041–2060) and far-future (2081–2100) periods.

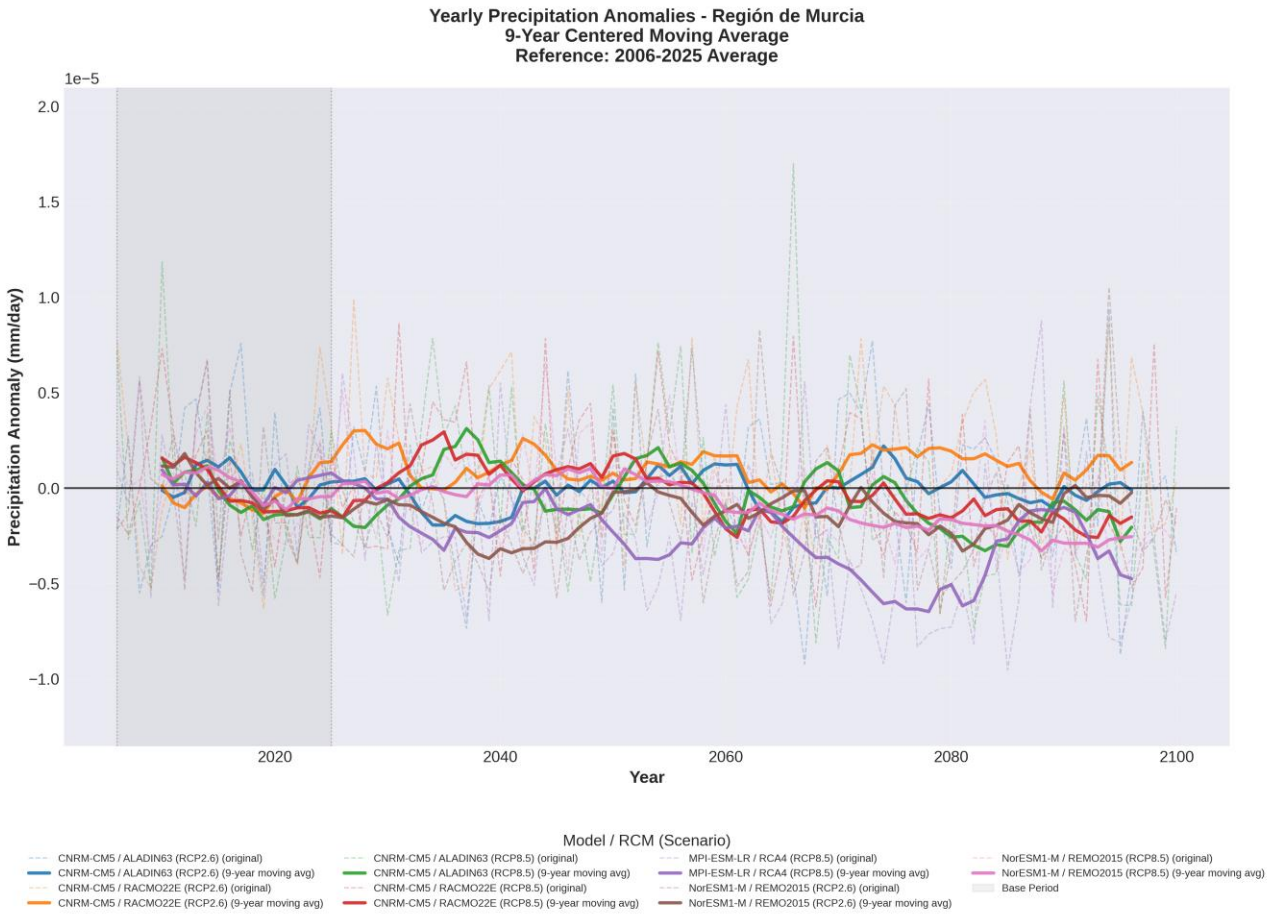

Figure 2-29 Evolution of precipitation averaged over the Región de Murcia for 4 GCM-RCM model combinations under RCP2.6 and RCP8.5, reference (2006–2020), near-future (2041–2060) and far-future (2081–2100) periods.

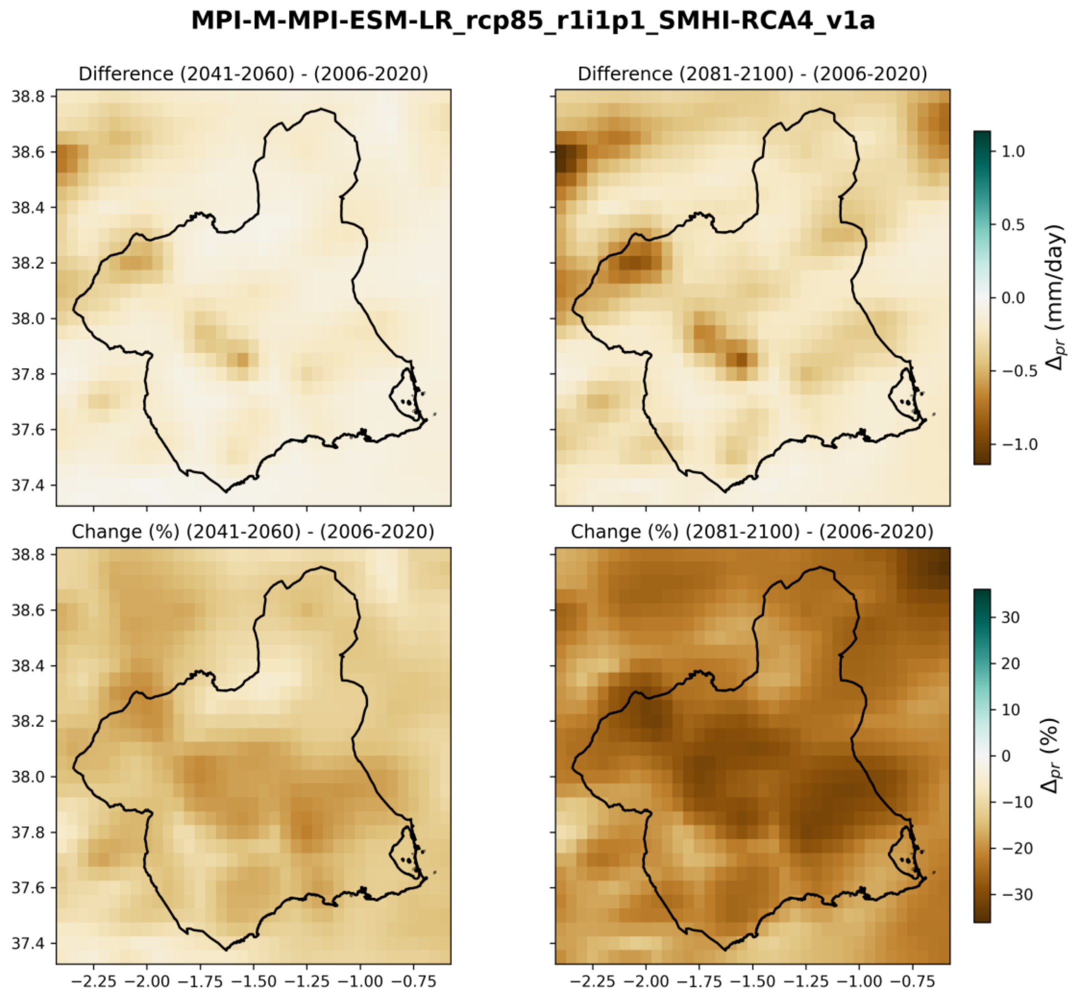

Figure 2-30 Example of projected precipitation change relative to the reference period, illustrating a case in which precipitation declines by around 40%.

Phase 2's contribution to this hazard therefore combines the multi-model temperature and precipitation trend analysis presented above with refinements to the exposure, vulnerability and economic-loss methodology; the expanded crop-specific evidence base for the latter is presented below, under Risk assessment.

2.3.1.2 Risk assessment

Phase 1's drought risk assessment combines MapSPAM crop-production data and GAEZ crop-value estimates with a single-value yield-response (K_i) factor (Doorenbos and Kassam, 1979) that Phase 1 itself flags as outdated and ill-suited to Murcian crops. Phase 1's reported economic-loss figures for this workflow are internally inconsistent across its own sections: §2.3.1.2 reports olive losses "totaling approximately €30,000 across the region" and barley losses "over €10 million," whereas its Conclusions instead state olive losses of "up to €16 million" and barley losses "below €1 million." Phase 2 reports both sets of figures rather than selecting one, and notes that almond losses could not be costed in Phase 1 because no production-data series was available. Phase 1 also benchmarks its underlying MapSPAM/GAEZ exposure data against official regional statistics and finds substantial divergence — almond under-represented by roughly 4×, olive over-represented by more than 4×, and citrus area reduced to a near-negligible 33 ha against an actual 40,135 ha —

leading Phase 1 to conclude that "the CRA cannot provide a reliable estimate of drought impacts on this high-value sector."

First, Phase 1's single-value yield-response factor (K_i; Doorenbos and Kassam, 1979), applied to three crops (olive, almond and barley), is replaced with a full FAO-56 dual crop-coefficient parameterisation (Allen et al., 1998) for seven rainfed/dryland crops: barley, oats, wheat, olives, almond, wine grapes and pistachios (Table 2-21). These crops were selected because they combine agronomic relevance for rainfed agriculture in the Region of Murcia, availability of crop-specific FAO-56 parameters, availability of official ESAM production and price records, and spatial representability through SIGPAC/CREM rainfed land-use categories. Together, the compatible SIGPAC/CREM categories represented by these crops — arable cereals, tree nuts, olive groves and vineyards — cover approximately 2,618 km², equivalent to more than 80% of the regional rainfed agricultural surface identified in the CARM, estimated at around 3,170 km². The selection therefore broadens Phase 1's three-crop scope while focusing on the dominant rainfed agricultural systems for which a coherent regional exposure, vulnerability and economic-value basis could be constructed. Other crops were not included at this stage because they were either predominantly irrigated, lacked a sufficiently robust combination of crop-specific parameters and regional production/price information, or could not be spatially represented with enough consistency using the SIGPAC/CREM rainfed exposure approach. Second, Phase 1's MapSPAM/GAEZ production and value estimates, which Phase 1 itself found to diverge substantially from official regional statistics for several crops, are complemented with production volumes and field prices drawn directly from the Región de Murcia's official Statistics of Agriculture portal (ESAM; Table 2-22). Third, a spatially explicit rainfed-cropland exposure layer is built from SIGPAC parcel data and CREM/ECONET municipal crop-area statistics (Figure 2-31, Table 2-23). These three elements are integrated into the updated drought workflow to estimate expected losses for rainfed agriculture under the selected climate scenarios. The resulting outputs provide a more coherent and regionally grounded estimate than the Phase 1 results, which were affected by global exposure-data inconsistencies and generic crop assumptions. Phase 1's loss figures reported above are complemented below by new Phase 2 yield-loss estimates for rainfed crops, illustrated here for almond; these new Phase 2 outputs include percentage yield-loss estimates for the seven rainfed crops analysed and a corrected economic-loss estimate illustrated for almond. The monetary valuation should therefore be interpreted as a first corrected economic quantification rather than as a complete valuation for all crops; extending the same harmonised valuation to the remaining crops remains a task for future refinement and stakeholder validation.

Table 2-21 FAO-56 dual crop-coefficient and yield-response parameters for the seven dryland crops analysed in Phase 2

Crop parameter	*Barley*	*Oats*	*Wheat*	*Olives*	*Almond*	*Wine grapes*	*Pistachios*
FAO code	114	75	11	248	230	269	234
Clim	3	3	3	3	3	3	3
Kc(ini)	0.30	0.30	0.30	0.65	0.40	0.30	0.40
Kc(mid)	1.15	1.15	1.15	0.70	0.90	0.70	1.10
Kc(end)	0.25	0.25	0.25	0.65	0.65	0.45	0.45
LGP(f1)	0.111	0.111	0.111	0.082	0.083	0.133	0.104
LGP(f2)	0.333	0.333	0.333	0.247	0.250	0.267	0.271

Crop parameter	*Barley*	*Oats*	*Wheat*	*Olives*	*Almond*	*Wine grapes*	*Pistachios*
LGP(f3)	0.389	0.389	0.389	0.329	0.375	0.400	0.396
LGP(f4)	0.167	0.167	0.167	0.342	0.292	0.200	0.229
Season start	Day 319	Day 319	Day 319	Day 60	Day 32	Day 91	Day 91
Season end	Day 134	Day 134	Day 134	Day 59	Day 273	Day 243	Day 334
RD(1)	0.20	0.20	0.20	0.40	0.30	0.30	0.40
RD(2)	1.00	1.00	1.20	1.50	1.70	1.50	2.00
DF	0.55	0.55	0.55	0.65	0.45	0.45	0.50
Type	1	1	1	3	3	2	3
Ky	1.00	1.00	1.15	0.90	0.85	0.85	0.80

Note: Kc(ini), Kc(mid) and Kc(end) are the FAO-56 initial, mid-season and late-season crop coefficients; LGP(f1)–LGP(f4) are the fractions of the total growing-period length assigned to the initial, development, mid-season and late-season growth stages; RD(1) and RD(2) are the initial and maximum effective rooting depths (m); DF is the soil-water depletion fraction for no stress; Type denotes the FAO-56 crop-group classification used to select stress-response behaviour; and Ky is the yield-response factor (Doorenbos and Kassam, 1979) relating relative yield decline to relative evapotranspiration deficit. FAO code and Clim follow the crop and climate-zone coding used in the FAO-56/CROPWAT reference tables. Source: FAO-56 (Allen et al., 1998), as applied to the seven crops analysed in Phase 2; wine grapes and pistachios are added relative to Phase 1's three-crop (olive, almond, barley) scope.

Crop-specific production volumes and field prices used to scale these parameters into an indicative economic-exposure metric were obtained from ESAM (Estadísticas Agrarias de la Región de Murcia; https://esam.carm.es/estadisticas-agricolas/) rather than from Phase 1's MapSPAM/GAEZ layers. Production figures are long-run averages (2012–2023 or 2012–2024, depending on data availability for each crop) intended to smooth year-to-year weather-driven fluctuations; field prices are weighted averages of monthly origin prices over 2020–2024 (Table 2-22).

Table 2-22 Average production, average field price and indicative exposure value for the seven dryland crops analysed in Phase 2 (source: ESAM)

Crop	*Production (t)*	*Price (€/t)*	*Value (M€)*
Almond	25,979.00	4,749.31	123.38
Olive	49,266.00	1,072.10	52.82
Wine grapes	68,813.00	650.00	44.73
Barley	33,636.00	223.08	7.50
Oats	18,903.00	233.83	4.42
Wheat	13,933.00	244.26	3.40
Pistachios	244.26	10,000.00	2.44

Note: value is the simple product of average production and average price, presented here as an indicative economic-exposure metric rather than a loss estimate; no climate-hazard scenario has been applied to it (see main text). The olive price is derived from ESAM's virgin-olive-oil price assuming a 25% average extraction yield, as ESAM does not publish a direct field price for olives destined for oil production.

To locate these crops spatially, Phase 2 combines agricultural-parcel geography from SIGPAC 2026 with official municipal crop-area statistics published by CREM/ECONET. SIGPAC provides the spatial base, since it identifies agricultural parcels together with their land use and irrigation coefficient, while CREM/ECONET provides the official statistical source of crop area at municipal scale. Municipal SIGPAC parcels were combined into a single vector layer, restricted to parcels with an irrigation coefficient of zero (i.e. rainfed/dryland parcels). SIGPAC land uses were then reclassified into groups compatible with the crops analysed: cereals and aromatic crops (wheat, barley, oats, lavender, lavandin) to arable land; almond, pistachio and carob to tree nuts and their mixed-use combinations; olive to olive-grove uses and olive mixtures; and grapevine to vineyard uses and vineyard mixtures.

Because SIGPAC records the broad agricultural use of a parcel rather than the specific crop grown, the resulting parcel classification should be read as a potentially compatible surface area rather than an exact parcel-level cartography of the crops analysed. To reconcile this with official figures, each municipality's CREM/ECONET crop area was distributed proportionally across the compatible SIGPAC parcels within that municipality, so that each parcel receives a weighted area in proportion to its share of the municipal compatible-SIGPAC surface. The resulting vector layer of rainfed parcels therefore reproduces the official CREM/ECONET area at the municipal level while distributing it spatially according to compatible-parcel location; it provides a spatially coherent approximation for exposure and vulnerability analysis but should not be read as an exact parcel-level inventory of crops. Within the arable-land category, the cereal area was further apportioned among wheat, barley and oats in proportion to each crop's share of regional production; all tree-nut area was treated as almond; and mixed-crop parcels, which together account for under 1% of regional production, were excluded from the crop-specific exposure analysis.

Figure 2-31 shows the resulting region-wide classification, with three example areas highlighted to illustrate the parcel-level detail achieved; Figures 2-32 to 2-34 show each of these areas in detail.

Table 2-23 SIGPAC-derived rainfed (dryland) land-use classification for the CARM, by category

Land-use category	*Number of parcels*	*Area (ha)*	*Share (%)*
Arable land (cereals)	152,133	139,593.40	44.04
Tree nuts	77,545	86,928.81	27.42
Unclassified	178,686	55,200.33	17.41
Olive groves	74,850	18,885.35	5.96
Vineyards	15,361	15,729.62	4.96
Tree nuts and olive groves	1,344	553.25	0.17
Olive groves and fruit orchard	264	55.39	0.02
Tree nuts and vineyards	67	21.81	0.01
Vineyards and olive groves	163	14.61	<0.01
Vineyards and fruit orchard	22	2.01	<0.01
Total	500,435	316,984.58	100.00

Note: categories combining two land uses (e.g. tree nuts and olive groves) correspond to SIGPAC parcels recorded under a mixed or associated use; together they account for under 1% of the total classified area and were excluded from the crop-specific exposure analysis (see main text).

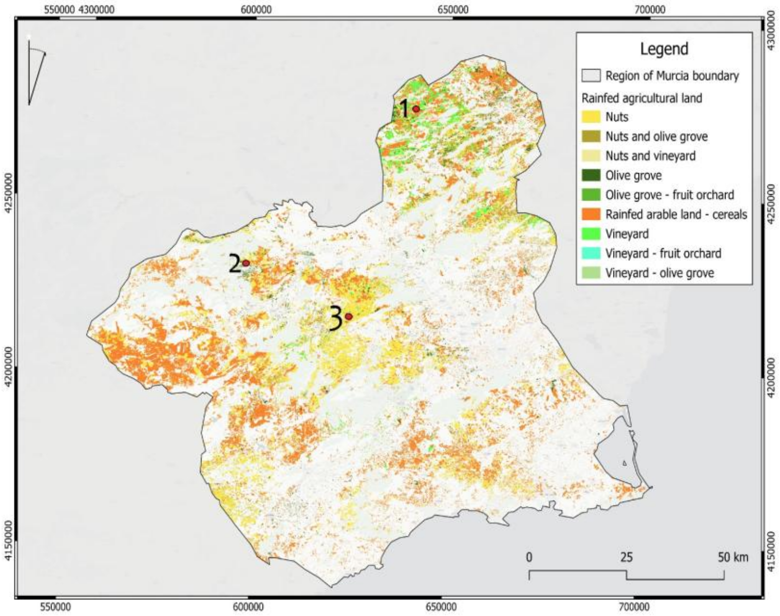

Figure 2-31 SIGPAC-derived classification of rainfed (dryland) agricultural land in the CARM, with three example zoom areas indicated (see Figures 2-32–2-34).

Table 2-23 summarises the resulting classification by category, in number of parcels, area and share of the total rainfed surface identified.

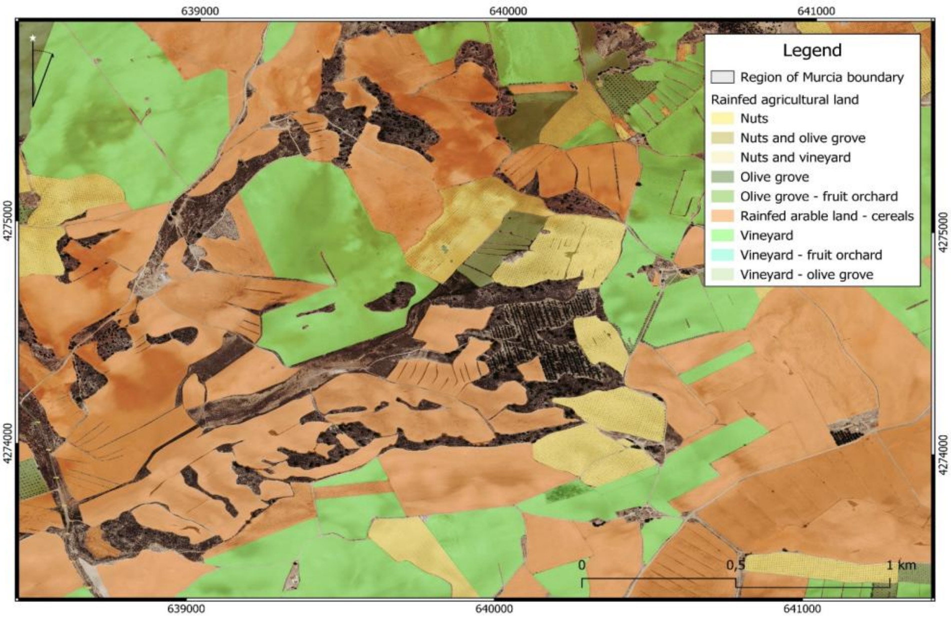

Figure 2-32 Parcel-level detail of the SIGPAC-derived classification for zoom area 1 (see Figure 2-31).

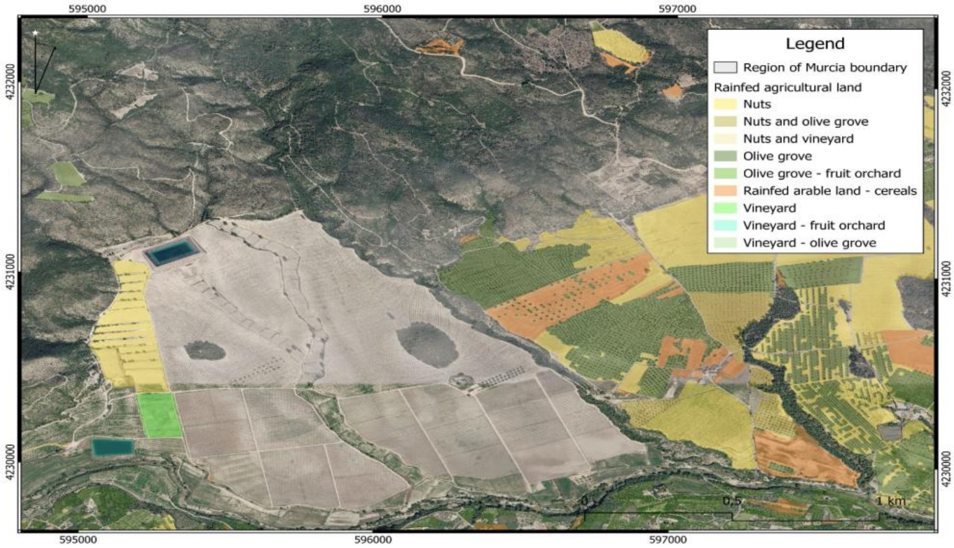

Figure 2-33 Parcel-level detail of the SIGPAC-derived classification for zoom area 2 (see Figure 2-31).

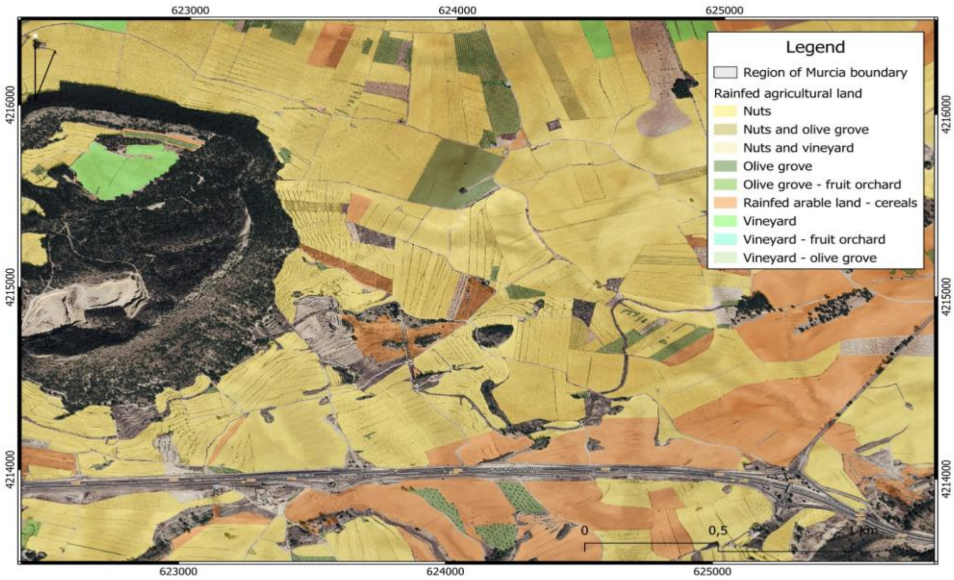

Figure 2-34 Parcel-level detail of the SIGPAC-derived classification for zoom area 3 (see Figure 2-31).

Taken together, the FAO-56 parameterisation, the ESAM-sourced production and price data and the SIGPAC/CREM-ECONET exposure layer presented above constitute a refined methodological basis for this workflow's risk assessment.

This workflow has been substantially revised relative to Phase 1. In its previous form, crop losses were computed against a baseline of unconstrained (potential) production. The aim here is instead to isolate the additional impact attributable to climate change on top of current cultivation conditions, rather than the total loss in a territory that already carries a structural water deficit. Losses are therefore calculated relative to the reference period, comparing the yield simulated under each future scenario with the yield obtained under reference-period climate. This removes the effect of the water stress already present under current conditions and isolates the yield variation attributable specifically to the projected climate changes, providing a more representative estimate of climate change's incremental impact on agricultural production.

To streamline the workflow, all EuroCordex data were clipped and interpolated using a bilinear model onto a regular 0.05° longitude/latitude grid covering the Región de Murcia (CARM). The fixed input fields required for the calculation — available water capacity, elevation and others — were interpolated onto the same grid. The crop-loss model, with a minor modification for arid zones, was then run for each of the periods described above.

Computing this yield for both the reference period ($Y_{r,ref}$) and the future scenario ($Y_{r,fut}$), the additional loss attributable to climate change is estimated as:

$$LCC = 100 \times (1 - Y_{r,fut} / Y_{r,ref})$$

Applying this methodology yields the percentage loss for each crop analysed in this workflow. As an illustrative example, results are presented below for almond under the MPI-ESM/SMHI-RCA4 climate model chain (RCP8.5) (Figure 2-35); full graphical and tabular results for all seven CARM crops (almond, barley, oats, olives, pistachios, wheat and wine grapes), periods and model chains analysed are provided separately in the Supporting Documentation (Section 5), package SI_Workflow_#1_CropYield_Dashboards_RCP8.5.zip, doi: 10.5281/zenodo.21064524.

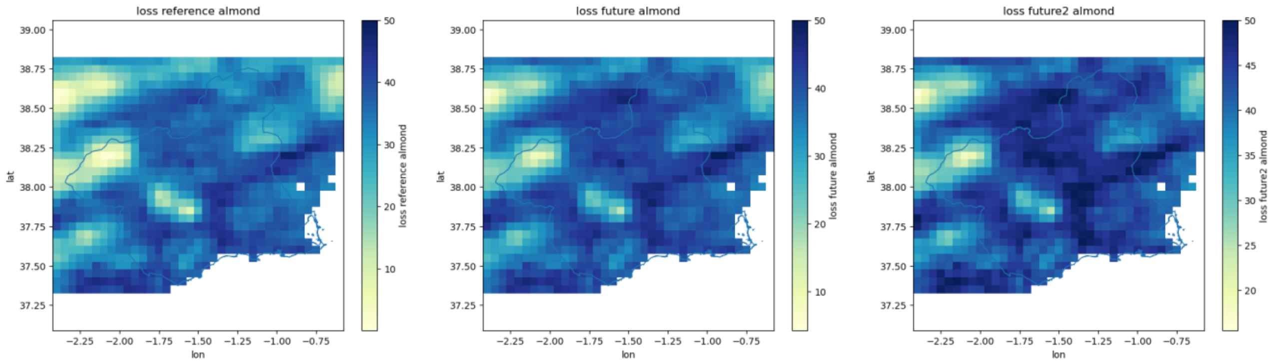

Figure 2-35 Estimated almond yield loss (%) relative to unconstrained (potential) production, for the reference period (2006–2020), near future (2041–2060) and far future (2081–2100), left to right.

Results show losses that increase progressively toward the far future. Notably, losses already reach significant values under the reference period itself, which should approximate present-day conditions: for almond, present-day production reductions of up to 30% are estimated, rising to locally over 50% in the far future. This is broadly consistent with the region's comparatively low almond yield per hectare relative to other Spanish growing regions.

Losses relative to the reference period — which isolate the increment attributable specifically to climate change — are shown in Figure 2-36. For almond, these relative losses range from around 15% to nearly 30% by the end of the century in the region's northernmost areas.

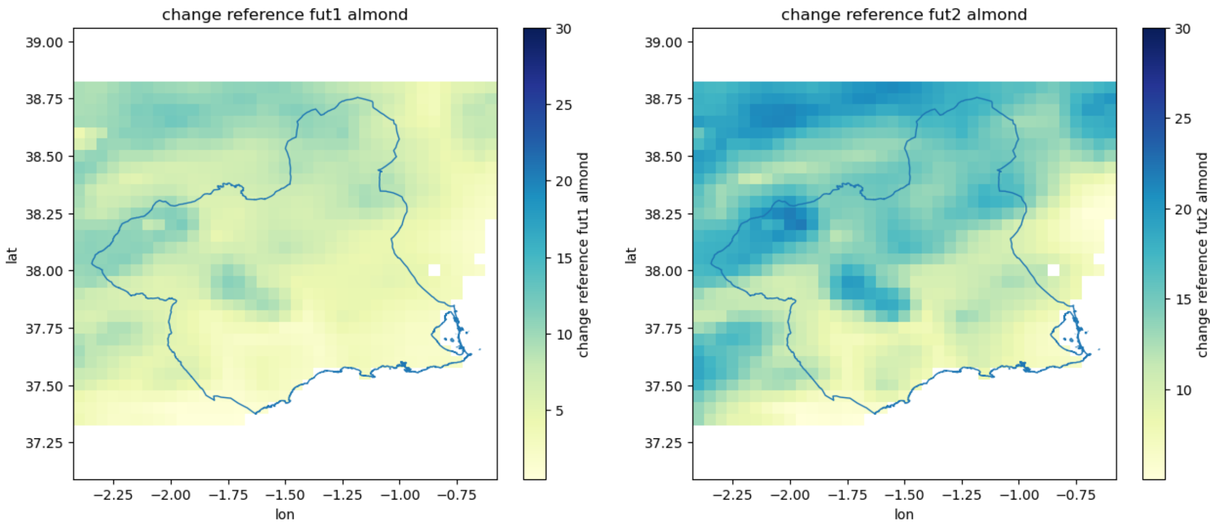

Figure 2-36 Almond yield loss (%) attributable to climate change, relative to the reference period, for the near future (2041–2060, left) and far future (2081–2100, right).

A consolidated view of these results for the illustrative MPI-ESM/SMHI-RCA4 (RCP8.5) chain is given in Figure 2-37, which reproduces in a single dashboard the absolute yield loss for the reference period, near future and far future (cf. Figure 2-35) together with the corresponding relative loss for each future horizon versus the reference period (cf. Figure 2-36).

During preparation of this report, the loss-calculation method used in an earlier iteration of this workflow was found to overestimate economic losses substantially, owing to a methodological error subsequently corrected. Figure 2-38 illustrates this for almond under the MPI-ESM/SMHI-RCA4 (RCP8.5) chain, far future (2081–2100): panel (a) shows almond cultivated area as a percentage of total municipal area; panel (b) shows the per-cell economic loss obtained under the original method, reaching over €1.2 million in the worst-affected cells; panel (c) shows the same loss under the corrected method, with a maximum of around €325,000 per cell. Aggregated regionally, almond production within the rainfed extent analysed is valued at approximately €123 million (≈25,979 t) for the reference period; the original method estimated an associated annual loss of approximately €55.2 million, while the corrected method reduces this to approximately €17 million per year. Losses attributable to climate change therefore remain significant, but materially smaller than initially estimated, and the corrected figures are the ones reflected throughout this section.

This corrected estimate should nonetheless be read as a lower bound rather than a full accounting of drought-related risk to almond cultivation. The yield-loss model underlying Figures 2-35 to 2-38 is calibrated on long-term climatic water deficit and does not explicitly capture two further mechanisms reported for the Region of Murcia during the severe 2023–2024 drought: heat damage to flowering and fruit-set under extreme spring temperatures, and outright die-off of mature trees under prolonged extreme water stress. Regional sources reported that the 2024 drought killed almond and vineyard trees outright in affected areas (La Opinión de Murcia, 2024), with around 12% of the Region's dryland plantations lost (ORM, 2024a), more than 160,000 ha at risk and an estimated €146 million in associated losses (ORM, 2024b), and €4.5 million in regional aid mobilised specifically for almond growers (ORM, 2024c). Because tree loss and flowering-stage damage represent a discrete loss of productive capacity rather than a marginal yield reduction, neither is captured by the percentage yield-loss metric used in this workflow; the true economic exposure of almond cultivation to drought and heat extremes in the Region may therefore exceed the corrected estimate above.

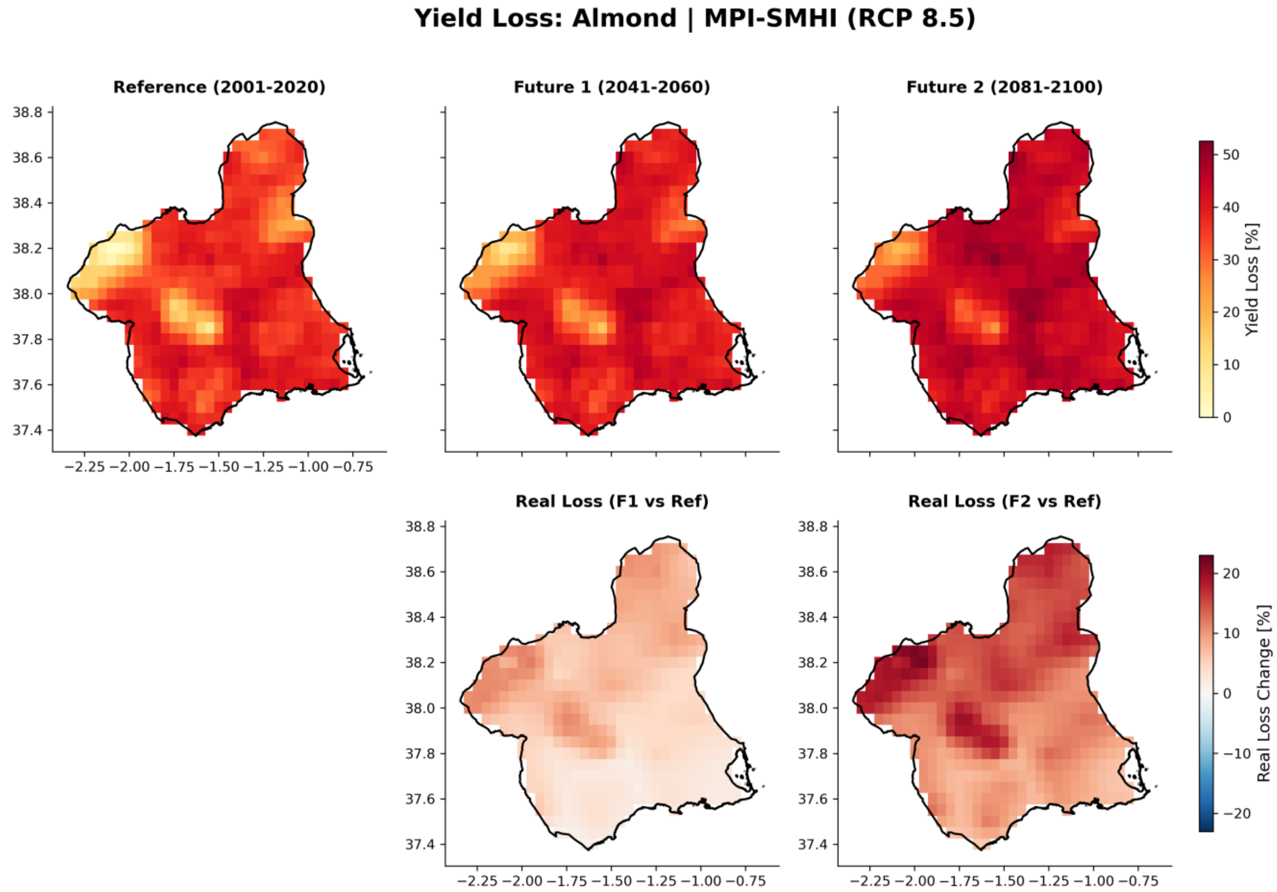

Figure 2-37 Summary dashboard for almond under the MPI-ESM/SMHI-RCA4 (RCP8.5) chain, consolidating absolute yield loss (%) for the reference period (2001–2020), near future (2041–2060) and far future (2081–2100) (top row), and the corresponding relative loss attributable to climate change for each future horizon versus the reference period (bottom row).

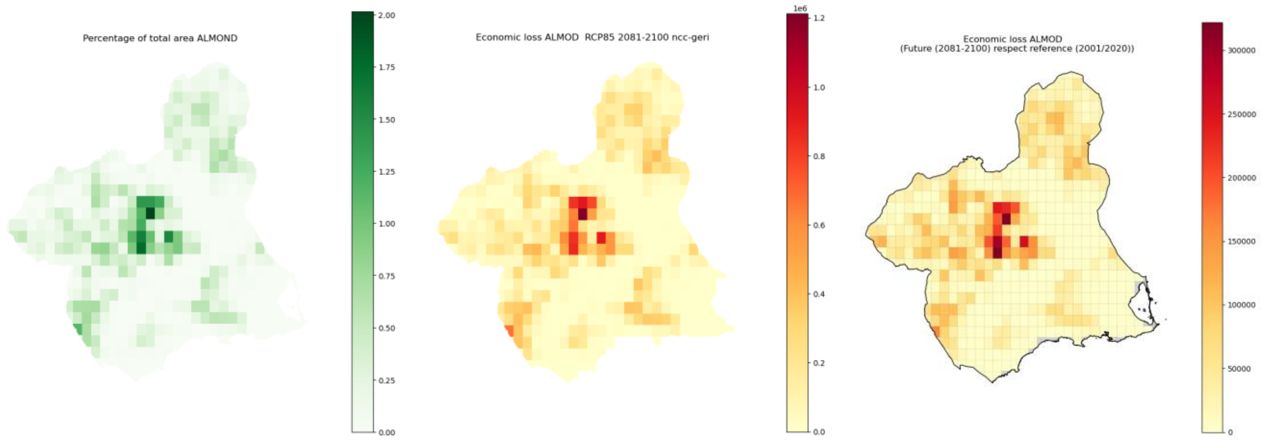

Figure 2-38 Spatial distribution underlying the loss-calculation comparison for almond, far future (2081–2100, RCP8.5): (a) almond cultivated area as a percentage of total municipal area; (b) economic loss under the original calculation method; (c) economic loss under the corrected calculation method, relative to the reference period (2001–2020).

2.3.2 Workflow #2: Coastal and river floods

Table 2-24 Data overview workflow #2

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
JRC river-flood depth maps, RP10/100/500, ~90 m resolution (Europe-wide coverage).	JRC depth-damage curves, combined with country-specific economic parameters (native CLIMAAX Toolbox output).	LUISA/Copernicus land use, ~100 m resolution.	Aggregate economic damage (M€) by land-use category and return period; CARM-wide hotspot maps. D1 result: €7,614M (RP10) to over €11,100M (RP500).
JRC maps as above, cross-checked against CNIG national flood hazard maps, RP10/100/500, 1 m native resolution (official Spanish flood mapping system, MITECO/SNCZI lineage).	Huizinga et al. (2017) depth-damage curves, applied via the open-source DamageScanner library — independent of the JRC curves used in D1.	LUISA cross-checked against SIOSE (national cadastre); both homogenized to 50 m, reprojected to EPSG:25830, and clipped to the CARM boundary.	Flooded area (km²) and economic damage (M€) for four hazard×exposure combinations (JRC+SIOSE, JRC+LUISA, CNIG+SIOSE, CNIG+LUISA) × 3 return periods, by land-use category — enabling attribution of the damage estimate to hazard-map source vs. land-use source.
Phase 2 (coastal): bathtub-type, hydraulic-connectivity inundation model developed by the University of Murcia, run over the IGN/PNOA 5 m Digital Terrain Model (MDT05, ETRS89/UTM, COG format), continuously swept in 1 cm increments of sea-level rise from 0 to 100 cm producing a separate “connected/active” and “residual/drainage” raster at every centimetre.	Continuous hyperbolic-tangent parametrisation of the CLIMAAX depth–damage table — $D(H) = ½[1 + \tanh((H−μ)/(σ\sqrt{2}))]$ — with land-use-specific μ/σ fitted and validated against real insurance-claim and municipal data from the September 2019 Los Alcázares flood (MAE = 2.8% residential, 1.2% infrastructure).	SIOSE (national land-occupation database, IGN/CNIG), grouped into LUISA-comparable classes using the same crosswalk applied to river floods (Row 2 above).	Flooded area and depth distribution by municipality across the full SLR sweep, including topographic critical-height (inflection) points; municipal and CARM-wide economic damage under the RCP4.5/RCP8.5 × 2050/2100 sea-level scenarios.

2.3.2.1 Hazard assessment

Phase 1 already flagged a sizeable hazard-data discrepancy for this workflow. Comparing the JRC-derived flood layer used in the CLIMAAX Toolbox against Spain’s official national flood-mapping system (SNCZI, MITECO), Phase 1’s Table 2-4 reports floodable areas of 179.6 km² (SNCZI) versus 120.7 km² (CLIMAAX/JRC) at RP10, 406.6 versus 145.4 km² at RP100, and 549.1 versus 165.6 km² at RP500 — an underestimation by the JRC-based layer of −33%, −64% and −70% respectively, which D1 attributes to the coarser (~90 m) resolution of the European hazard layer relative to SNCZI’s much finer national mapping. Phase 1’s text does not unambiguously state whether this specific comparison covers the full 11,316 km² CARM or a narrower extent: it ties the table generically to “the Region of Murcia” before separately narrowing to the Metropolitan Area of Murcia for a follow-up spatial-consistency check. This ambiguity should be clarified with the Phase 1 team and is not assumed away below.

Phase 2 deepens this hazard-source comparison, independently re-deriving flooded area for the entire CARM — explicitly clipped to the regional administrative boundary — under two hazard-map sources (JRC, and CNIG, Spain’s official national flood-hazard mapping system, at 1 m native resolution) crossed with two exposure layers, at the three standard return periods. Table 2-25 reports the flooded-area results by hazard-map source (collapsing across exposure layer, since the hazard layer alone determines the flooded extent).

Table 2-25 Flooded area by hazard-map source and return period (km²), CARM-wide

Hazard-map source	*RP10 (km²)*	*RP100 (km²)*	*RP500 (km²)*
JRC (European layer)	135.66	192.13	217.21
CNIG (national layer)	218.97	507.37	671.04
Ratio CNIG/JRC	*1.61×*	*2.64×*	*3.09×*

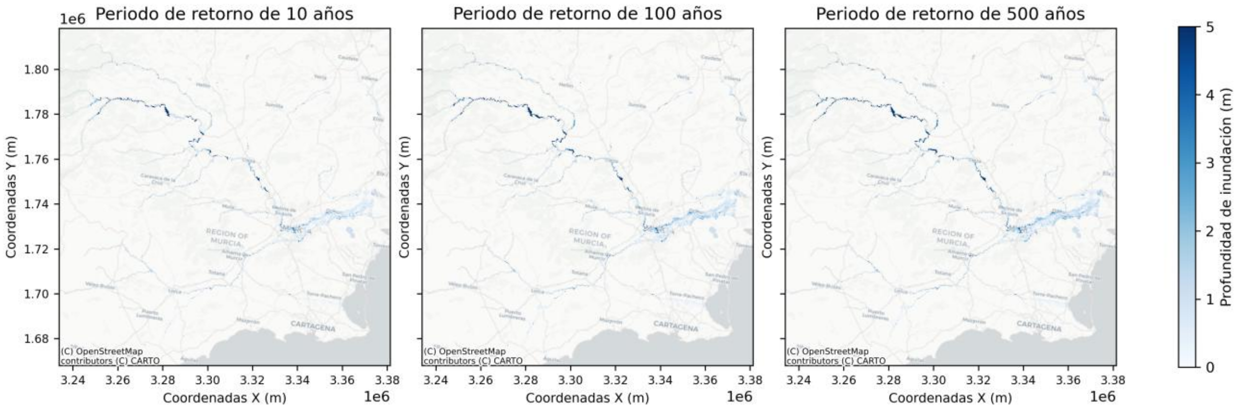

Figure 2-39 JRC/European river-flood hazard map for the CARM (based on JRC hazard layers).

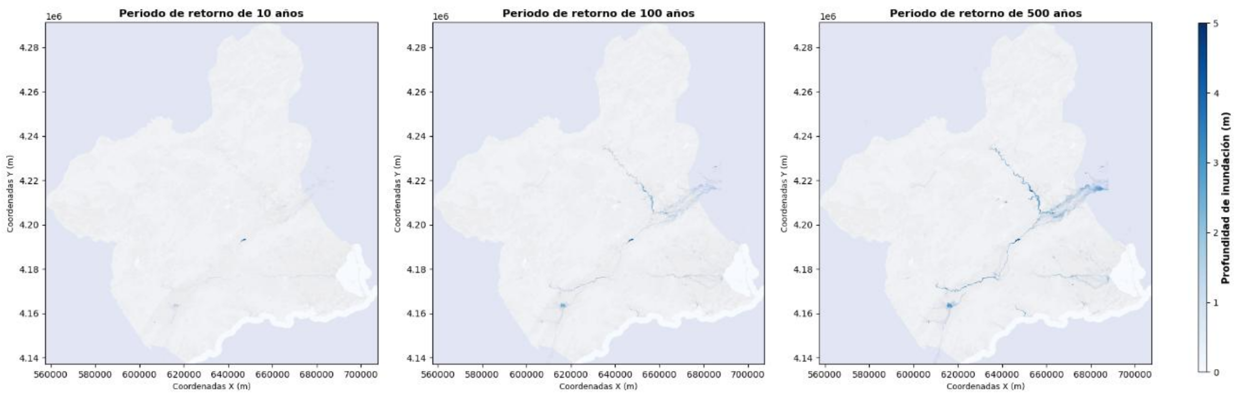

Figure 2-40 CNIG national river-flood hazard map for the CARM (based on CNIG/SNCZI hazard layers).

Although the absolute figures in Phase 1's Table 2-4 and in Table 2-25 are not directly comparable given the spatial-extent ambiguity noted above, both comparisons point in the same direction and grow in the same way: the gap between the European JRC layer and the high-resolution Spanish national reference (SNCZI/CNIG) widens as the return period increases — from −33% to −70% in Phase 1's comparison, and from a 1.61× to a 3.09× area ratio in Phase 2's CARM-wide comparison. This convergent, independently derived pattern reinforces hazard-map source as a primary driver of the divergence in flood-extent estimates between Phase 1 and Phase 2, and, as shown below, in the resulting damage estimates.

As a visual cross-check, Figure 2-41 reproduces Phase 1's own flood-depth map for the Murcia metropolitan area at four return periods (D1, Figure 2-19), generated under the same JRC/European hazard source as Figure 2-39 above. Phase 1's map covers only the metropolitan extent rather than the full CARM, so it is not a substitute for the CARM-wide comparison in Table 2-25, but the pattern it shows — flooding concentrated along the main river channel, widening only moderately between the 10- and 500-year return periods — is qualitatively consistent with the CARM-wide JRC layer in Figure 2-39, offering an independent, if partial, cross-check of Phase 1's own hazard mapping within the area both analyses cover.

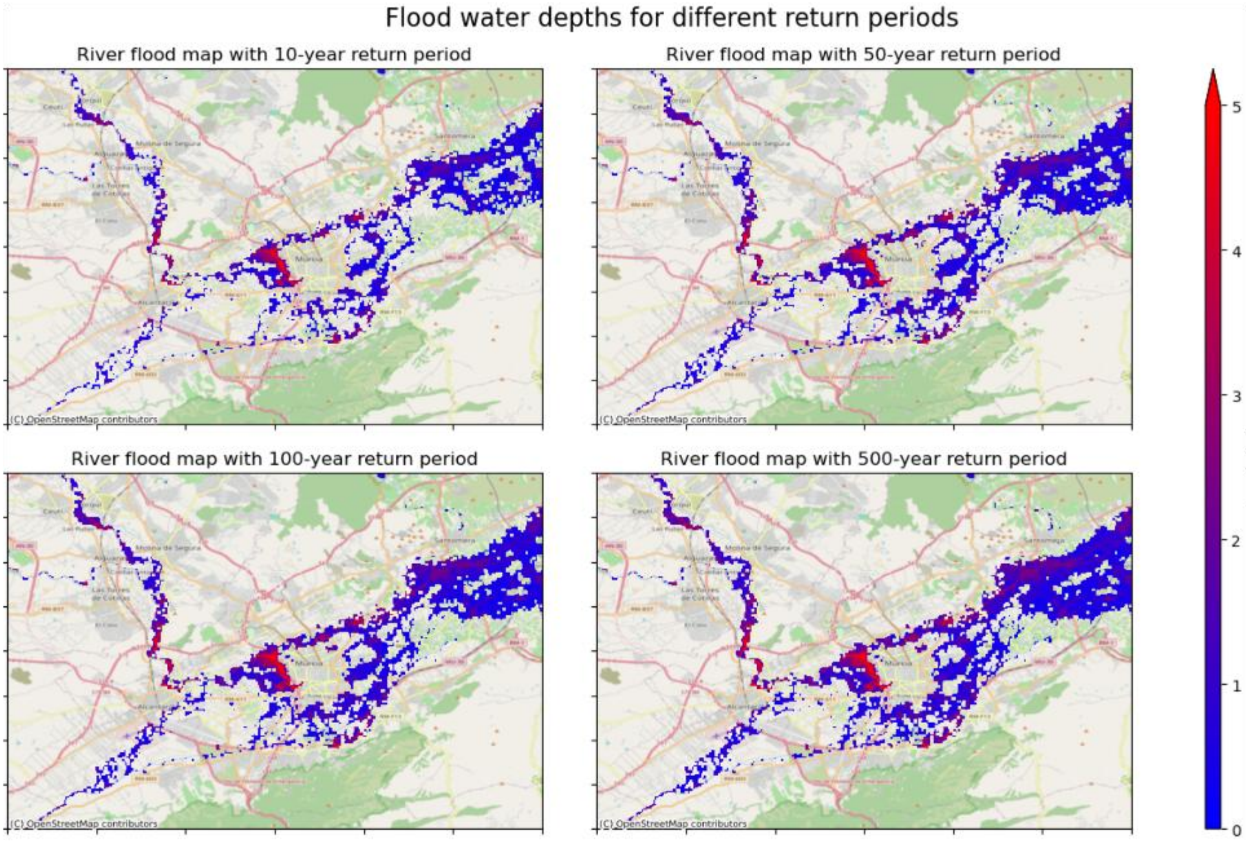

Figure 2-41 Phase 1's flood water depth map for the Murcia metropolitan area, for the 10-, 50-, 100- and 500-year return periods (source: D1, Figure 2-19, reproduced for comparison).

For coastal floods, Phase 2 departs methodologically from Phase 1's discrete-scenario approach, as already flagged in Table 2-2 above. Phase 1's own coastal data overview combined GTSMv3.0 extreme sea levels (IPCC AR6 / NASA Sea Level Projection Tool, present-day and mid-century RCP8.5) with Deltares' global bathtub-inundation maps over two alternative 90 m DEMs (MERIT-DEM and NASADEM), evaluated at seven discrete return periods (2, 5, 10, 25, 50, 100 and 250 years). D1 found the flooded area to depend "only slightly" on return period — GTSMv3.0's own extreme sea levels range from just 0.4 m (RP5) to 0.6 m (RP100) — but to depend heavily on the choice of DEM: Phase 1's Table 2-9 shows MERIT-DEM producing flooded areas roughly 155–225% larger (up to ~3.2×) than NASADEM for the same scenario, a gap that narrows somewhat from 2018 to 2050 but never closes.

Phase 2's response to this DEM-driven uncertainty, developed in collaboration with the University of Murcia, was twofold. First, spatial resolution was increased: a 1 m DEM was tested and compared against a 5 m product, the difference in flooded area found to be below 1%, so the IGN/PNOA 5 m Digital Terrain Model (MDT05, ETRS89/UTM, Cloud Optimized GeoTIFF format) was adopted as the best trade-off between detail and full coastal coverage. Second, and more fundamentally, Phase 1's discrete return-period/DEM-pair comparison was replaced by a continuous sweep of sea-level rise (SLR) from 0 to 100 cm in 1 cm increments, run through a bathtub-type model with hydraulic connectivity developed at the University of Murcia. The reason for the change was precisely the uncertainty associated with SLR scenarios themselves: rather than evaluating hazard at a handful of discrete return-period/year combinations, Phase 2 evaluates it continuously across the full plausible SLR range, generating a separate "connected/active" flood raster and a "residual/drainage" raster for every centimetre — the latter capturing water that remains trapped in topographic depressions after the tide recedes.

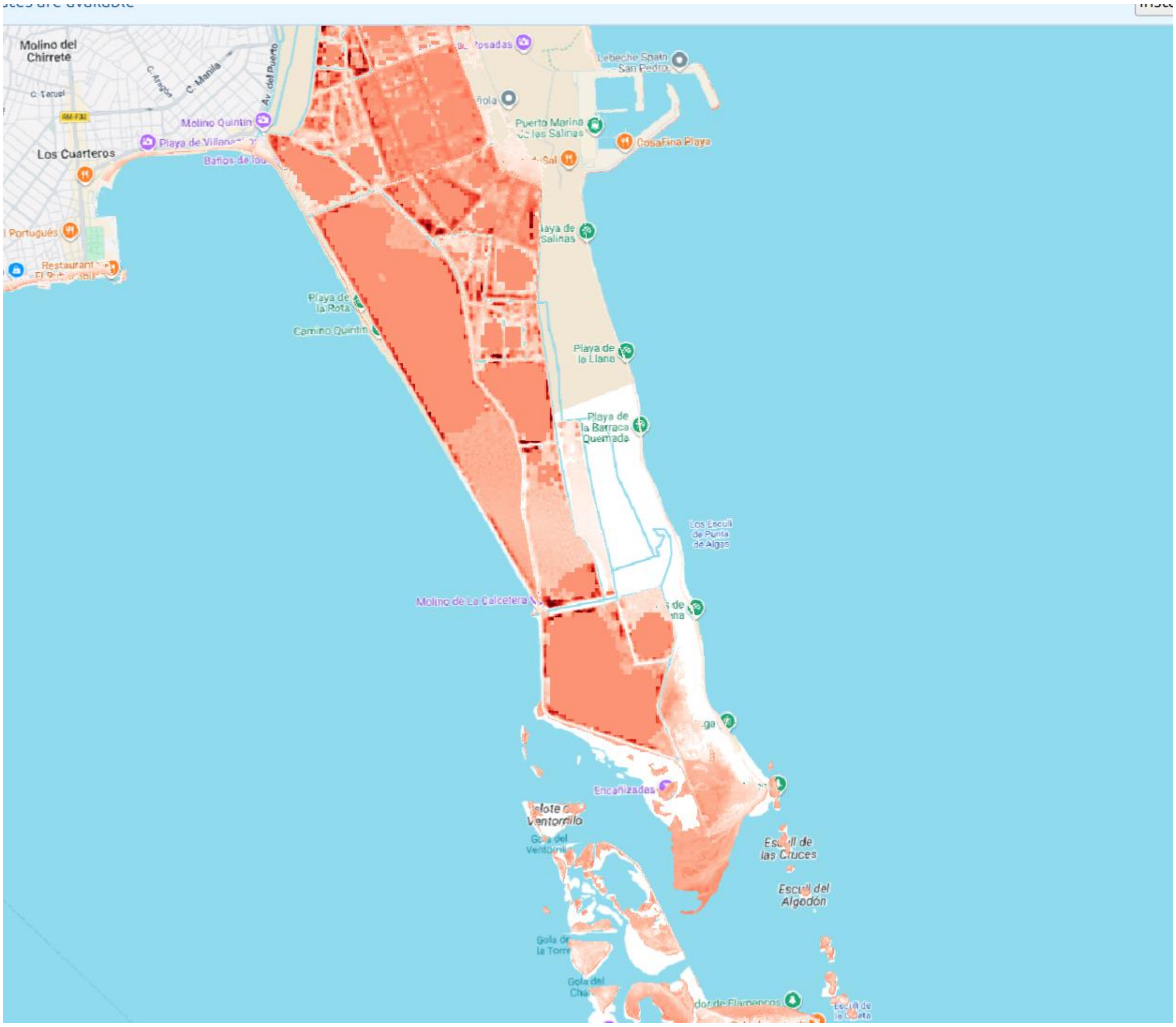

Figure 2-42 Flood-extent overlay for the La Manga / Mar Menor coastal strip — Phase 1's principal coastal study area — under the Phase 2 bathtub-with-hydraulic-connectivity model.

Figure 2-43 Parcel-scale detail achieved with the IGN/PNOA 5 m MDT05 digital terrain model, illustrating the resolution gain over Phase 1's 90 m DEMs.

Figure 2-44 illustrates the practical effect of the continuous SLR sweep for a single municipality, San Pedro del Pinatar, mapping how the flooded extent grows across the four scenarios also used in the regional and municipal figures below: SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5. For comparability with the RCP-based nomenclature used elsewhere in this report, SSP2-4.5 corresponds to RCP4.5 and SSP5-8.5 to RCP8.5; SSP1-2.6 and SSP3-7.0 are additional bounding scenarios with no direct RCP counterpart in the regional figures that follow. The largest flood extent is overlaid in red beneath progressively smaller ones, so the map reads as a nested set of scenario outlines rather than four separate panels.

Figure 2-44 Flood-extent scenarios for San Pedro del Pinatar under SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5 (SSP2-4.5 ≈ RCP4.5; SSP5-8.5 ≈ RCP8.5), largest extent overlaid beneath smaller ones.

This finer, continuous treatment surfaces a finding Phase 1's coarse, discrete approach could not detect: municipality-specific critical (inflection) heights at which flooded area increases abruptly rather than gradually with sea-level rise. For San Pedro del Pinatar, Phase 2 identifies inflection points at approximately 37 cm and 65 cm of SLR — visible in the area curve in Figure 2-48 below — thresholds with no analogue in Phase 1's seven discrete return periods, and a direct, demonstrable benefit of the continuous-sweep methodology adopted for Phase 2.

2.3.2.2 Risk assessment

The flooded-area divergence documented above propagates into economic damage. Table 2-26 reports Phase 2's damage estimates for all four hazard×exposure combinations, alongside Phase 1's Phase 1 result, for direct comparison.

Table 2-26 Estimated flood damage by hazard-map source, exposure source and return period (M€)

Source / combination	RP10 (M€)	RP100 (M€)	RP500 (M€)
JRC + SIOSE	620.59	1,158.01	1,474.46
JRC + LUISA	684.70	1,205.35	1,518.71
CNIG + SIOSE	1,593.29	5,708.39	10,382.56
CNIG + LUISA	1,687.87	5,889.54	10,279.28
D1 (Phase 1)	**7,614**	*not reported*	**> 11,100**

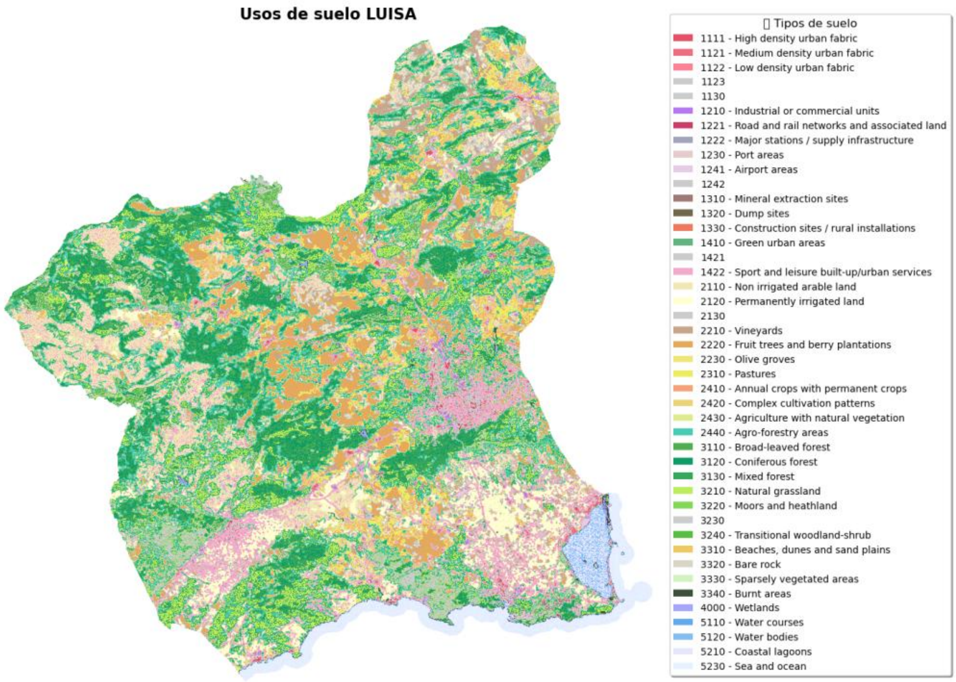

Figure 2-45 LUISA land-use classification of the CARM, one of the two exposure layers used in Phase 2's damage estimation.

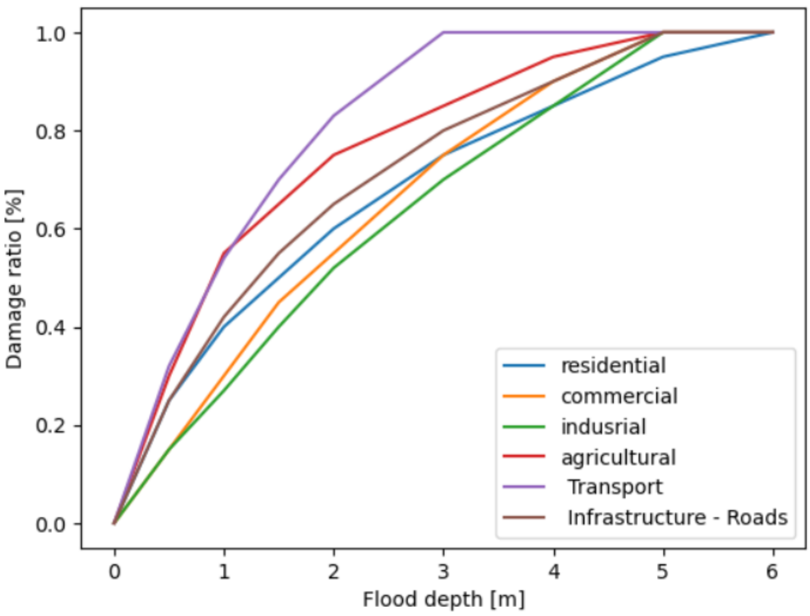

Figure 2-46 Huizinga et al. (2017) depth-damage curves by land-use category.

Comparison with Phase 1. Phase 1's aggregate river-flood damage estimate (€7,614M at RP10, rising to over €11,100M at RP500; D1 does not report an intermediate RP100 value) sits well above all four Phase 2 combinations at RP10 — roughly 4.5× the highest Phase 2 estimate (CNIG+LUISA, €1,687.87M) — but converges much closer to, while still exceeding, the CNIG-based Phase 2 combinations at RP500 (€10,382.56M and €10,279.28M), a gap of only around 7–8%. In other words, the relative size of the discrepancy is not constant: it narrows sharply as the return period increases.

Likely drivers of the discrepancy. Two complementary lines of evidence point to where this discrepancy originates. First, hazard-map source has a large, quantifiable effect within Phase 2's own internal comparison: switching from JRC to CNIG hazard maps, holding the exposure layer fixed, multiplies estimated damage by approximately 2.5× at RP10, 4.9× at RP100, and 6.8–7.0× at RP500 — mirroring the widening hazard-source gap documented in the Hazard assessment above. Second, a substantial residual gap remains even after accounting for hazard source: Phase 2's JRC+LUISA combination nominally shares its hazard and exposure inputs with Phase 1's Phase 1 pipeline, yet Phase 1's damage estimate is still around 11× higher at RP10 (€7,614M vs. €684.70M) and at least 7.3× higher at RP500 (>€11,100M vs. €1,518.71M). Because hazard and exposure are nominally held constant in this specific comparison, this residual points to the vulnerability/damage-valuation step — Phase 1's JRC depth-damage curves combined with undocumented "country-specific economic parameters" applied internally by the CLIMAAX Toolbox, versus Phase 2's independent application of the curves— as the most defensible explanation for the part of the gap that hazard-map source alone cannot account for.

Convergent evidence. Despite the large difference in absolute magnitude, both analyses agree on which land-use categories drive the damage. Phase 1 identifies "Permanently irrigated land" and "Fruit trees and berry plantations" as the most affected categories, each exceeding €2,000M under RP500; Phase 2's highest-damage combination (CNIG+LUISA, RP500) identifies the same two categories as the largest contributors €2,280.75M; €1,712.58M; respectively). This agreement on the dominant damage drivers, despite the gap in absolute totals, is reassuring evidence that both pipelines are capturing the same underlying exposure pattern.

Caveats. Both pipelines share an important limitation that should temper how precisely either euro figure is read: neither vulnerability function has been calibrated or validated against observed flood-loss data for the CARM. Phase 1 itself notes that "the loss curves were adopted as acceptable without further adjustment" and flags them as "a potential source of uncertainty that warrants closer examination and refinement in the next phase of the analysis"; this Phase 2 analysis similarly notes that the Huizinga curves derive from international case studies not calibrated to local conditions. Given this, the absolute damage figures from both pipelines should be read as order-of-magnitude indicative, and the size of the residual gap attributed above to methodology should itself be treated as an estimate, not a precise decomposition.

Recommendation for Phase 3. To reconcile the two estimates, Phase 3 should: (i) request the specific "country-specific economic parameters" applied by the CLIMAAX Toolbox in D1, to allow a like-for-like comparison against the Huizinga coefficients used in this Phase 2 analysis; (ii) where feasible, cross-validate at least one vulnerability function against observed local flood-loss records for a documented historical event in the CARM; and (iii) clarify directly with the Phase 1 authors the precise spatial extent underlying Phase 1's Table 2-4, to determine whether it is strictly comparable to the CARM-wide figures in Table 2-25.

Coastal risk assessment. Phase 1's coastal risk assessment (D1, Figure 2-16) reported total integrated losses by DEM database, year and scenario, finding — consistent with the hazard-side divergence documented above — that MERIT DEM losses reach up to three times NASADEM's for the same scenario, with both models showing markedly higher losses by 2050 than in 2018 (NASADEM: roughly +30% to +10% across return periods; MERIT DEM: around +10% across all return periods). Importantly, D1 does not isolate a coastal-specific aggregate damage figure in euros: Phase 1's own Conclusions chapter is explicit that its headline euro figures (€7,614M at RP10, rising to over €11,100M at RP500) refer to "the case of river floods," not coastal floods (see Table 2-19 and the river risk-assessment comparison above). A direct euro-for-euro comparison between Phase 1's coastal risk assessment and Phase 2's coastal damage results is therefore not possible on the basis of Phase 1's own report; the comparison below is necessarily qualitative, and Phase 2's municipality-level damage figures should be read as the first disaggregated economic assessment of coastal flood risk produced for this region, rather than as an update to a prior D1 number.

To translate flood depth into economic exposure, Phase 2 parametrised CLIMAAX's discrete depth–damage table with a continuous hyperbolic-tangent function, $D(H) = ½[1 + \tanh((H−\mu)/(\sigma\sqrt{2}))]$, fitted separately for each SIOSE land-use class (see Table 2-2 above). The fitted curves were validated against real insurance-claim and municipal data from the September 2019 Los Alcázares flood, for the two land-use types where local damage records were available: residential and infrastructure. Figure 2-47 compares the fitted model (solid lines) against the discrete CLIMAAX table values it is built from (dashed lines and markers) for both classes. The mean absolute error against the empirical 2019 event data is 0.028 (≈2.8%) for residential land use and 0.012 (≈1.2%) for infrastructure — both well within the order-of-magnitude uncertainty that Phase 1 itself flags for its own vulnerability curves (it states they were "adopted as acceptable without further adjustment" and identifies them as a source of uncertainty "that warrants closer examination") — and a calibration step Phase 2 can claim that Phase 1 explicitly could not.

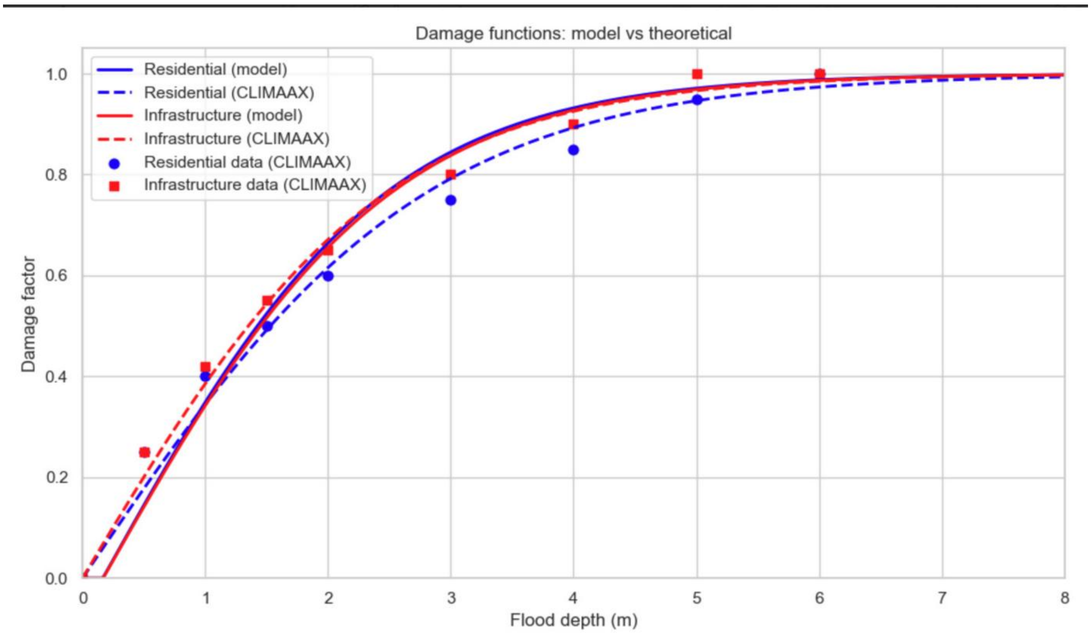

Figure 2-47 Validation of the continuous hyperbolic-tangent damage function against the discrete CLIMAAX depth–damage table and against real insurance-claim and municipal data from the September 2019 Los Alcázares flood, for residential and infrastructure land uses.

Figure 2-48 illustrates the resulting risk output for a single municipality, San Pedro del Pinatar, combining hazard, depth distribution and an infiltration-permeability metric across the full SLR sweep. The upper panel shows the statistical distribution of flood depth as a function of sea-level rise — the central marker is the spatial median, the thick and thin vertical bars are the 25/75 and 10/90 percentiles — separately for the “connected/active” flood phase (blue) and the post-recession “residual” phase (red); the convergence of the two lines indicates that a substantial share of the active flood volume remains trapped as residual standing water. The lower panel plots total flooded area for both phases and the Municipal Infiltration Parameter (green dashed line, right axis), which normalises active flooding against the municipality’s coastline length. The inflection points at approximately 37 cm and 65 cm of SLR — flagged in the Hazard assessment above — are visible here as abrupt steps in the area curve, marking topographic thresholds where small further increases in sea level produce disproportionate jumps in flooded extent. Vertical dashed lines mark the SLR values corresponding to RCP4.5 and RCP8.5 in 2050 and 2100.

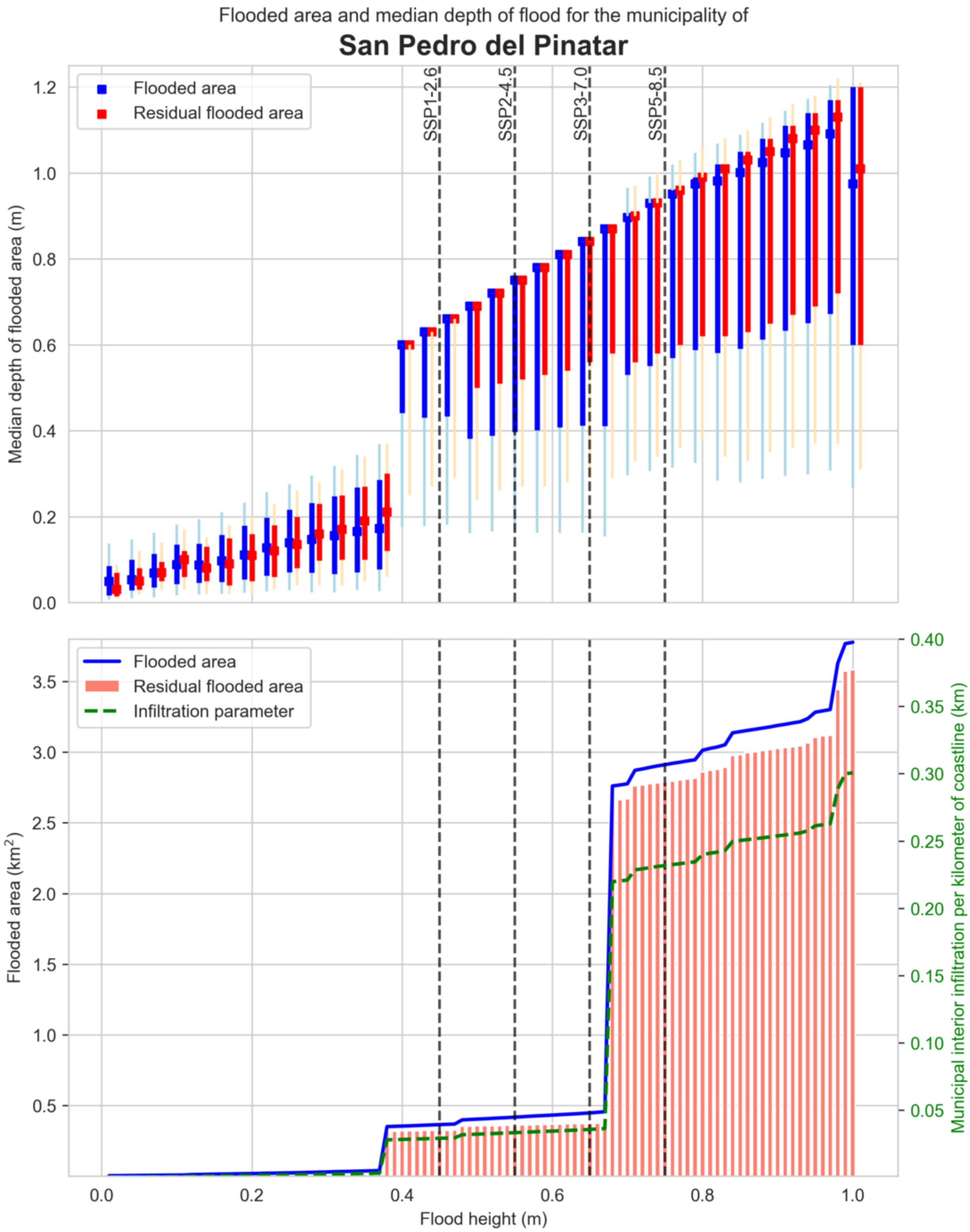

Figure 2-48 Flooded area and median flood depth for San Pedro del Pinatar across the full sea-level-rise sweep, with RCP4.5/RCP8.5 2050/2100 markers (SSP2-4.5 ≈ RCP4.5; SSP5-8.5 ≈ RCP8.5).

Figure 2-49 aggregates the same depth/area/infiltration metrics to the level of the whole Región de Murcia, providing the CARM-wide counterpart to the single-municipality example above and the basis for the region-wide damage figures that follow.

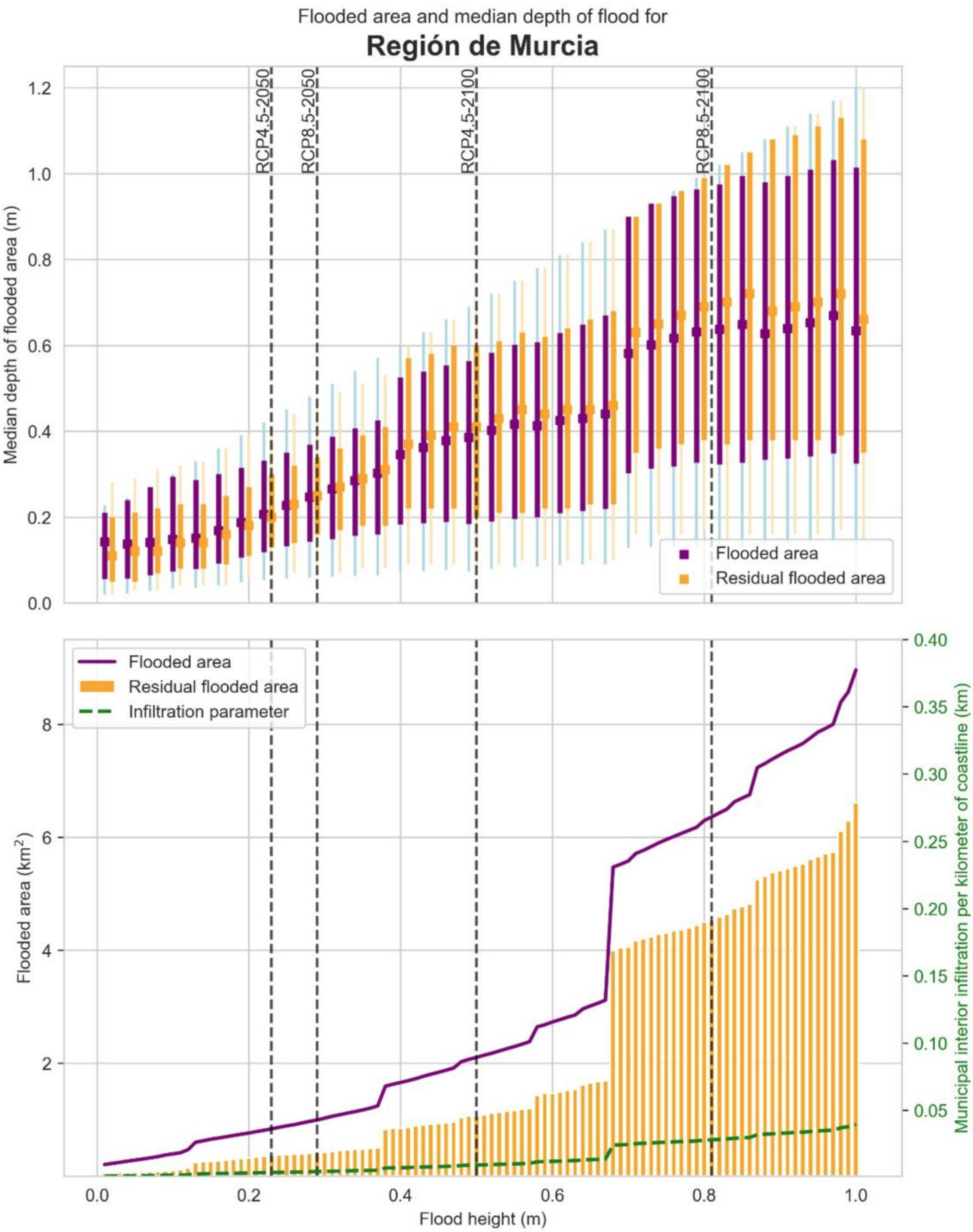

Figure 2-49 Flooded area and median flood depth for the Región de Murcia, aggregated across all affected coastal municipalities, under RCP4.5/RCP8.5 2050/2100.

Once flood depth is characterised at every point, the vulnerability functions above are applied pointwise and summed to obtain total economic cost by municipality. Figure 2-50 plots this economic loss for each of the eight coastal municipalities covered by this analysis — Águilas, Cartagena, Lorca, Mazarrón, San Javier, San Pedro del Pinatar, La Unión and Los Alcázares — across the SLR range, with Cartagena and San Javier emerging as the two highest-loss municipalities throughout.

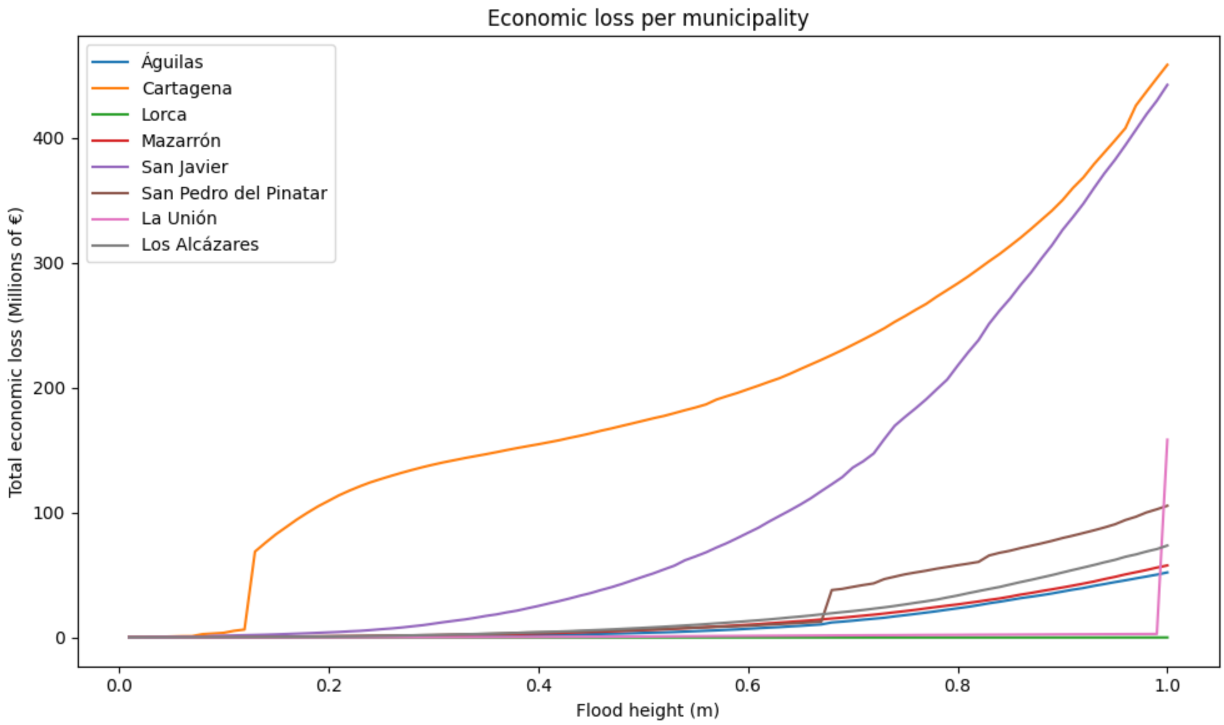

Figure 2-50 Estimated economic loss by municipality across the sea-level-rise range.

Cartagena and San Javier stand out as the two municipalities with by far the largest projected losses, each approaching €450 million at the upper end of the sea-level-rise range, roughly an order of magnitude above the other six municipalities. The two follow different trajectories: Cartagena's losses rise steadily from the lowest sea-level-rise increments onward, while San Javier's curve is comparatively flat through the first half of the range before accelerating sharply beyond approximately 0.6 m, the same critical-height pattern described for San Pedro del Pinatar above. La Unión shows the most extreme version of this non-linearity – losses stay near zero for almost the entire sweep before rising abruptly to roughly €160 million in the final centimetres of sea-level rise, overtaking San Pedro del Pinatar and Los Alcázares – while Lorca's coastal economic exposure remains negligible throughout.

Figure 2-51 breaks the region-wide damage total down by asset category — residential, industrial, infrastructure, agriculture, green areas and water bodies — for the four headline scenarios used throughout this section (RCP4.5 and RCP8.5 at 2050 and 2100), showing how the composition of damage, not just its magnitude, shifts with the scenario.

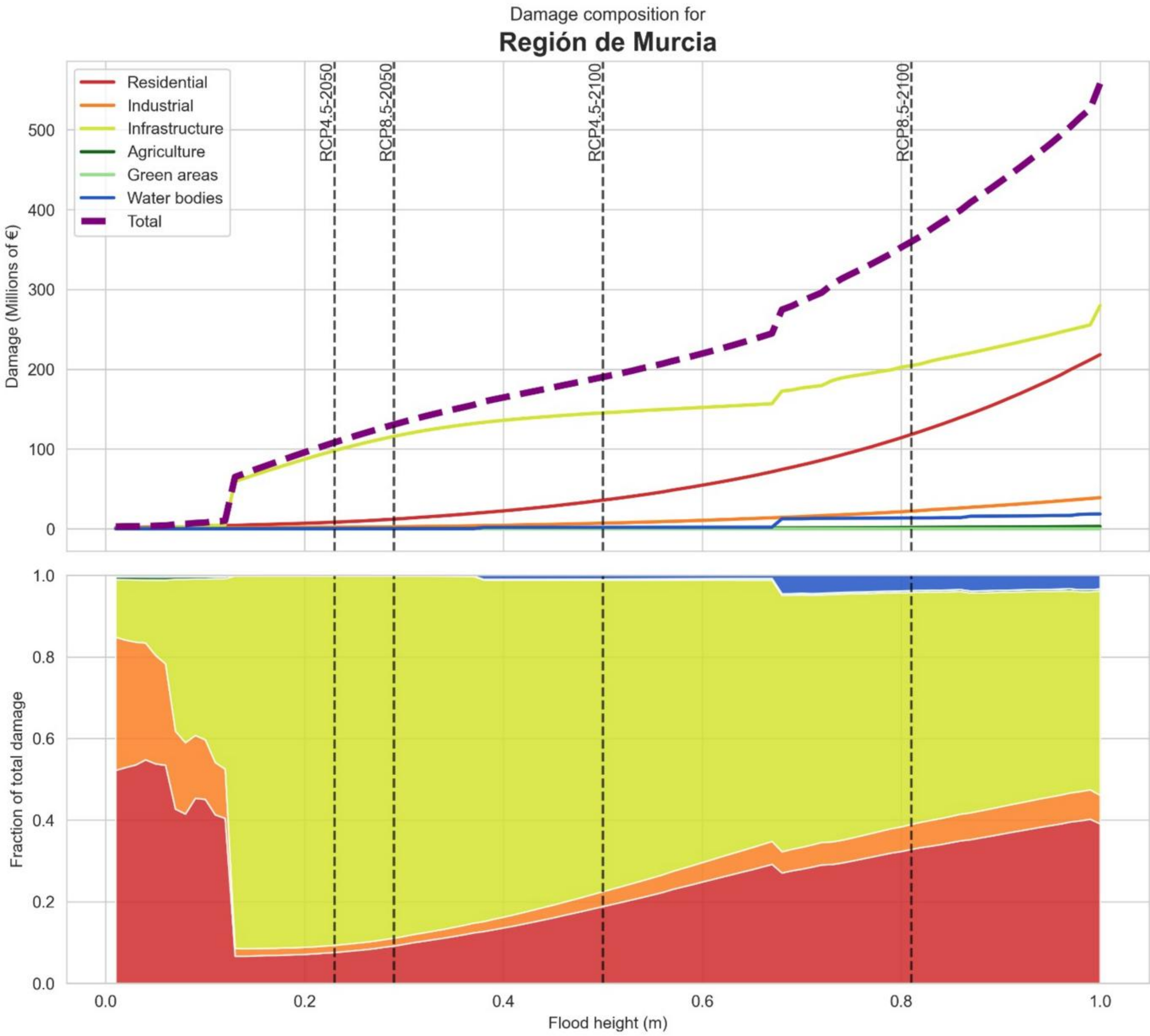

Figure 2-51 Damage composition by asset category for the Región de Murcia, under RCP4.5/RCP8.5 2050/2100. A municipality-level breakdown for Cartagena is given in Figure 2-53.

An alternative, municipality-resolved view of the same results is given in Figure 2-52: the inner ring shows each municipality's share of total flooded area and the outer ring its share of total economic cost, for the same four scenarios, using a single consistent legend across all four panels.

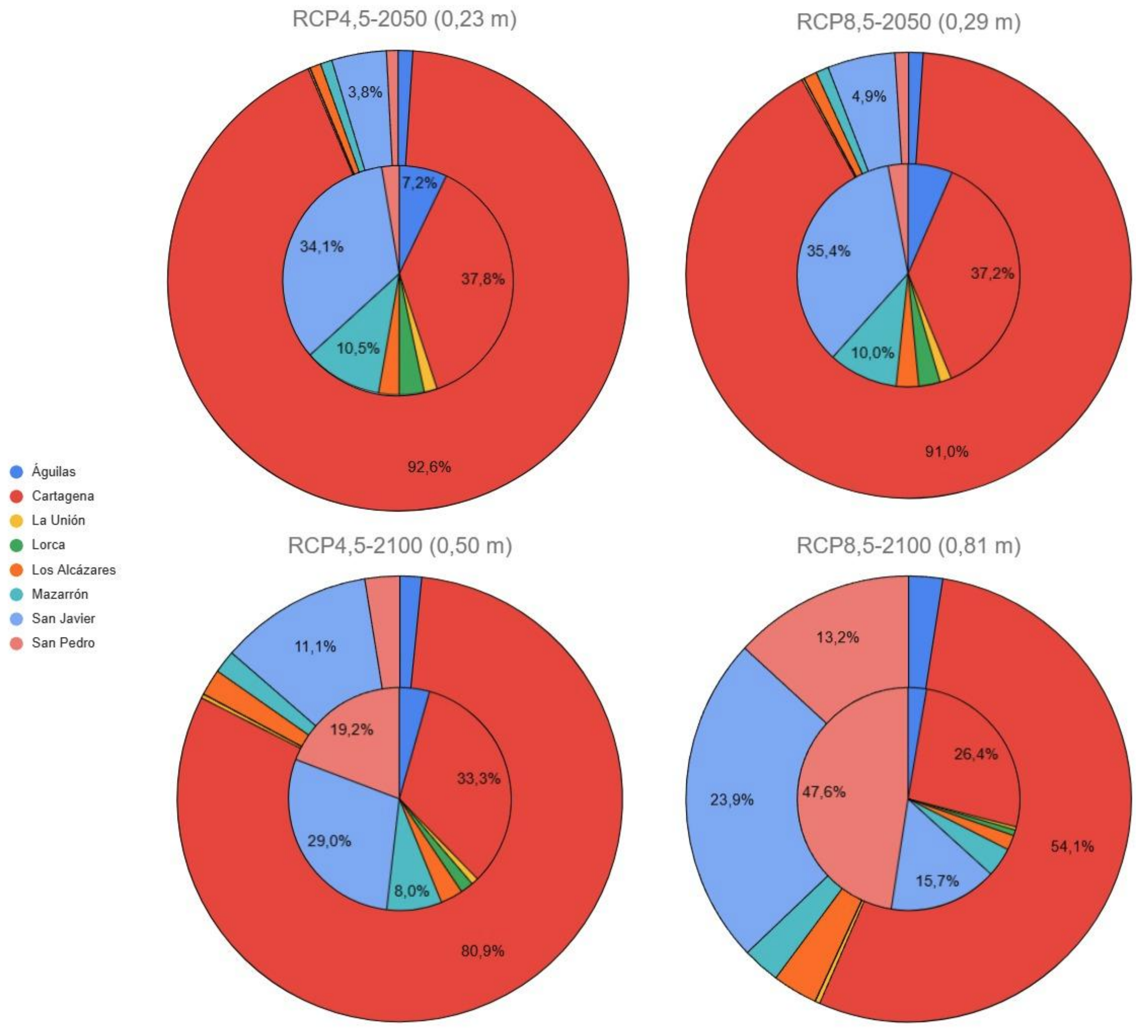

Figure 2-52 Municipal shares of total flooded area (inner ring) and total economic cost (outer ring) under RCP4.5-2050 (0.23 m SLR), RCP8.5-2050 (0.29 m), RCP4.5-2100 (0.50 m) and RCP8.5-2100 (0.81 m).

Cartagena, identified above as one of the two largest contributors to projected coastal damage, also has a category-level breakdown analogous to Figure 2-51 but specific to the municipality. Figure 2-53 shows this breakdown: absolute damage by asset category against flood height (top panel) and the same damage expressed as a share of the municipal total (bottom panel). The infrastructure-damage series shows an abrupt increase at approximately 0.12–0.13 m of flood height — a municipality-specific critical height not visible in the regional aggregate (Figure 2-51).

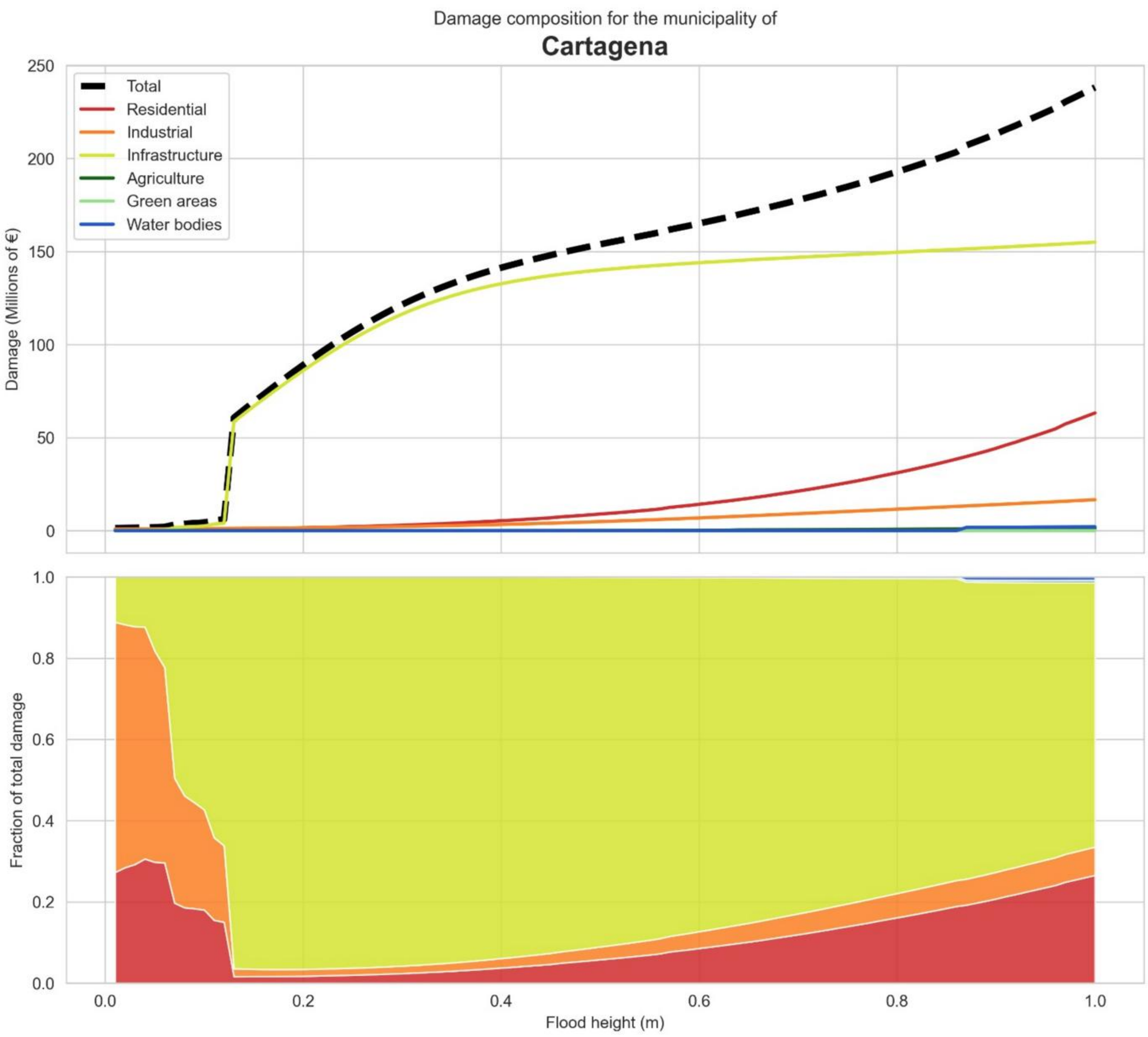

Figure 2-53 Damage composition by asset category for the municipality of Cartagena: absolute damage (top) and share of total damage (bottom), both against flood height.

Beyond the damage-cost outputs above, the Phase 2 coastal model also supports municipal land-use planning directly, by overlaying projected flood water depth on parcels currently classified as developable land. Figure 2-54 illustrates this application for the Salinas de Marchamalo area: projected water depth (0.001–0.646 m) under RCP8.5 (2100) is shown against developable land and points of interest, allowing planners to identify which currently undeveloped parcels would be exposed before committing them to development.

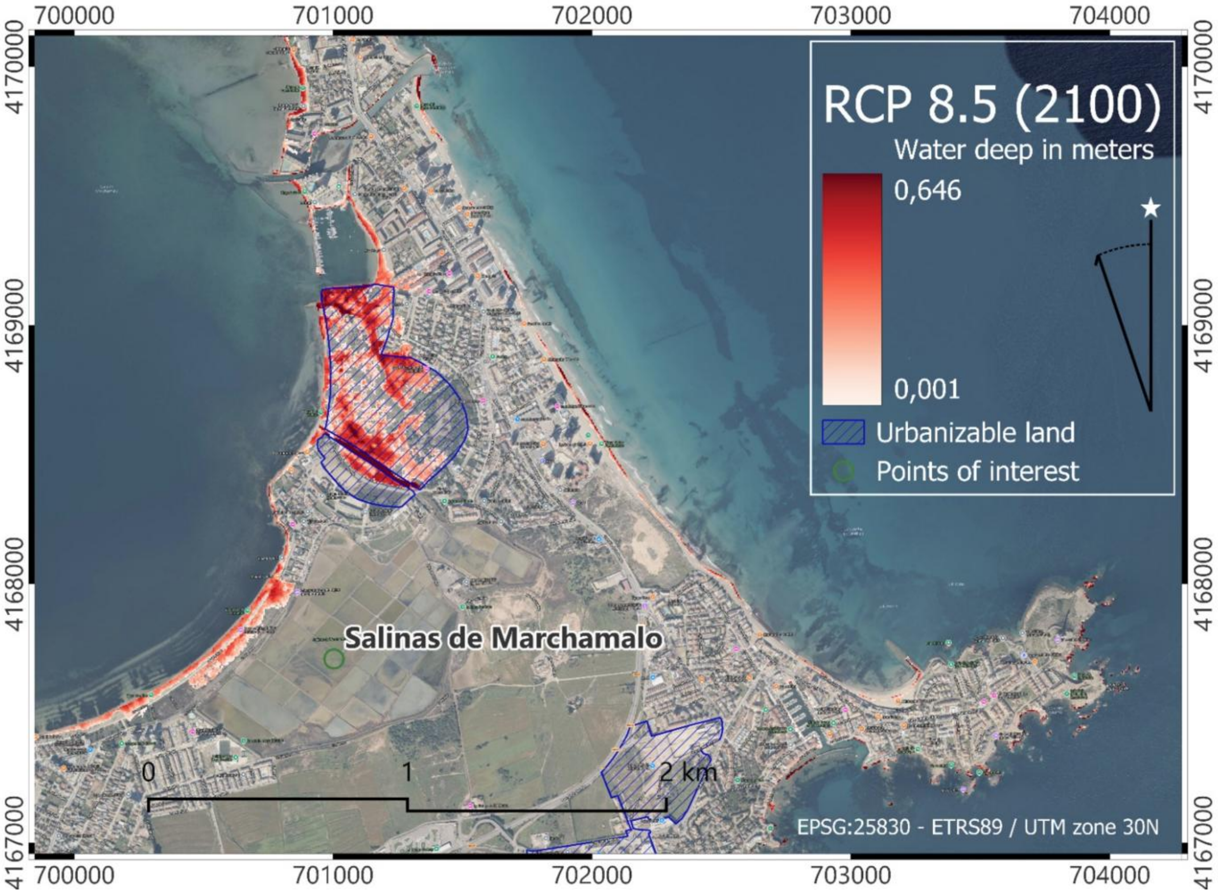

Figure 2-54 Projected flood water depth (0.001–0.646 m) under RCP8.5 (2100) overlaid on developable land and points of interest, Salinas de Marchamalo.

The same planning approach is illustrated for a second coastal area in Figure 2-55, which compares the more moderate RCP4.5 (2050) scenario (left) against the more severe RCP8.5 (2100) scenario (right) for an identical area, showing how the extent of projected water depth over developable land grows between the two planning horizons.

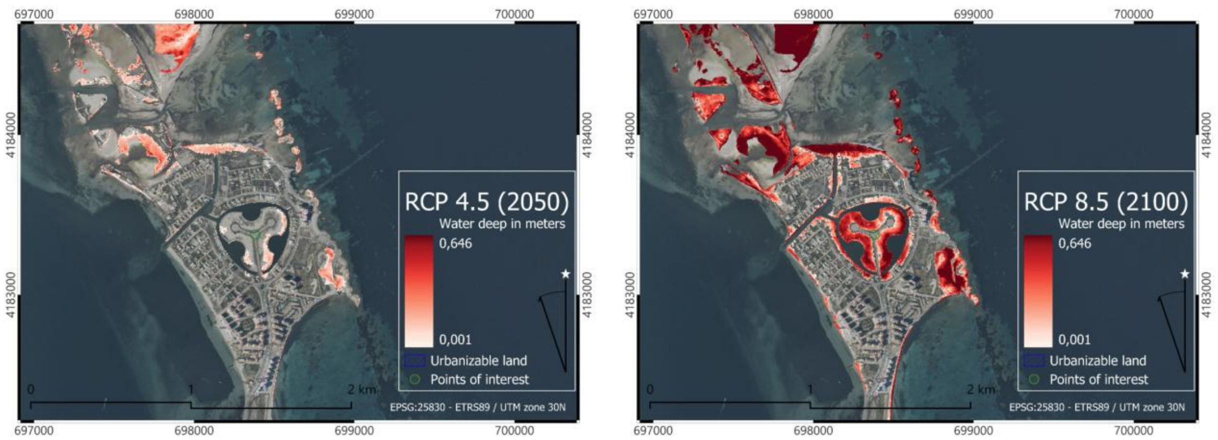

Figure 2-55 Projected flood water depth overlaid on developable land and points of interest for a second coastal area, under RCP4.5 (2050) (left) and RCP8.5 (2100) (right).

Comparison with Phase 1. These results cannot be benchmarked against a Phase 1 coastal damage baseline, for the reason noted above: none exists in Phase 1's own report. What can be said is that Phase 2's coastal risk assessment is, for the first time, disaggregated to the municipality level, validated against a real historical flood event, and continuous across the full plausible SLR range rather than confined to a handful of discrete scenarios — a substantive methodological advance over Phase 1's coastal workflow, even where, as here, it cannot be reduced to a single comparable euro figure.

2.3.3 Workflow #3: Heatwaves

Table 2-27 Data overview workflow #3

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
EuroHEAT dataset, 12 km grid (the only hazard layer in either workflow with an explicitly stated resolution), defining heatwave days via Tmax/Tmin percentile thresholds for July–August; RCP4.5/RCP8.5. Phase 1's table lists periods 1971–2000/2011–2040/2041–2070/2071–2100, while its operational text instead uses a 1986–2015 baseline with 2036–2065/2066–2095 horizons (D1, Table 2-14, §2.3.3.1). Not updated in Phase 2.	10×10 qualitative risk matrix combining heatwave hazard metrics with population exposure, rather than a continuous damage function. Population base restricted to residents aged ≥75, using stationary 2020 age-band density rasters — D1 itself flags this as likely to underestimate future vulnerability in an ageing region. Not updated in Phase 2.	EuroHEAT regional hazard layers combined with WorldPop population-distribution data, producing multi-scale exposure/risk maps (D1, Table 2-14). Not updated in Phase 2.	Heatwave frequency rising from ≈3 events/year at baseline to >50 events/year by late century under RCP8.5 (±10 events), with interior counties seeing an ≈10× increase and southern coastal counties an ≈8× increase; highest population-weighted risk in Campo de Cartagena and the Segura valley. Unlike floods and drought, D1 reports no monetary (€) damage figure for heatwave — risk is expressed only via frequency, relative multiples, population exposure and fatality counts (22 heat-related deaths in Murcia, summer 2025).

2.3.3.1 Hazard assessment

Phase 2 does not quantitatively re-run the heatwave workflow. This is not because heatwave risk is considered less relevant, but because the Phase 1 heatwave assessment did not show the same level of internal inconsistency or methodological divergence identified for the flood and drought workflows. The Phase 1 heatwave outputs are therefore retained as the quantitative baseline and are interpreted in Phase 2 together with stakeholder evidence on social vulnerability, public facilities, outdoor work, urban heat and health-related impacts. Phase 1's heatwave hazard assessment uses the EuroHEAT dataset (12 km grid, the only hazard layer in either workflow with an explicitly stated resolution), defining heatwave days via maximum/minimum temperature percentile thresholds for July–August, under RCP4.5 and RCP8.5 (D1, Table 2-14). Phase 1's table lists assessment periods of 1971–2000/2011–2040/2041–2070/2071–2100, while its operational analysis instead uses a 1986–2015 baseline with 2036–2065 and 2066–2095 horizons (D1, §2.3.3.1) — a discrepancy between Phase 1's own table and text that is likewise reported as found. D1 projects a sharp rise in heatwave frequency, from roughly 3 events/year at baseline to over 50 events/year by late century under RCP8.5 (±10 events; roughly half under RCP4.5), with interior areas seeing an approximately 10× increase and southern coastal areas an approximately 8× increase relative to the 1986–2015 baseline, and names the Region of Murcia as “one of the European hotspots” for this hazard. Recent named episodes include the 2022 heatwave (45.1°C, an unprecedented daily high) and summer 2025 — the warmest on record at the Alcantarilla station, with 21 days above 35°C in June 2025 alone, against a five-day average.

2.3.3.2 Risk assessment

Phase 1’s heatwave risk assessment uses a 10×10 qualitative risk matrix rather than a continuous damage function, combining hazard metrics with a population base restricted to residents aged ≥75 and stationary 2020 age-band density rasters — a simplification D1 itself flags as likely to underestimate future vulnerability in an ageing region. Vulnerable population concentrates in the south and southwest of the region, particularly Campo de Cartagena and the Segura valley (Vega Media and Vega Alta), with D1 projecting nearly the entire region to exceed medium risk by late century. Unlike floods and drought, D1 reports no monetary (€) damage figure for heatwave; risk is instead expressed through event frequency, relative multiples and population exposure, alongside reported mortality — D1 cites 22 heat-related deaths in Murcia in summer 2025, more than double the 2024 figure, with 13 fatalities in a single week of August.

2.3.4 Additional assessments based on local models and data

Beyond the workflow-specific updates presented in Sections 2.3.1 to 2.3.3, Phase 2 includes several additional analyses based on regional, national and local datasets. These analyses were not designed as separate hazard workflows, but as methodological refinements intended to test, validate or improve the Phase 1 results.

For agricultural drought, Phase 2 substantially updates the rainfed-agriculture risk assessment by integrating regional crop-specific parameters, official production and price data, and spatially explicit rainfed crop exposure. This update produces revised yield-loss estimates and a corrected economic-loss estimate illustrated for almond, while identifying remaining needs for local calibration, validation and extension of the economic valuation to all crops.

For river flooding, Phase 2 compares European and Spanish national hazard and exposure sources, including JRC and CNIG flood maps and LUISA and SIOSE land-use layers. This comparison shows how strongly the choice of hazard source affects estimated flooded area and economic damage.

For coastal flooding, Phase 2 adds a dedicated high-resolution sea-level-rise and damage assessment based on the IGN/PNOA 5 m DEM, hydraulic-connectivity modelling, a continuous sea-level-rise sweep and municipality-level damage estimation. This provides a more planning-relevant assessment of coastal exposure and damage than the coarser Phase 1 approach.

No equivalent local quantitative re-run was conducted for heatwaves in Phase 2. The Phase 1 heatwave workflow is retained as the quantitative baseline because it did not show the same level of internal inconsistency or data-source divergence identified for flood and drought. Its interpretation is nevertheless strengthened through stakeholder evidence on social vulnerability, public facilities, outdoor work, urban heat and health-related impacts.

2.4 Key Risk Assessment Findings

2.4.1 Mode of engagement for participation

REGMURCIA's stakeholder engagement and participation process is described in full in Section 2.1.5, including the institutional profile, role and rationale for selecting each participant, and a synthesis of all nine interviews completed for Phase 2 (IMIDA; DG IMAS; DG Industria Alimentaria y Asociacionismo Agrario; Dirección General de Ordenación del Territorio y Arquitectura; FECOAM; AMETSE; the Agencia Local de la Energía y Cambio Climático of the Ayuntamiento de Murcia; ITREM; and Ecologistas en Acción Región de Murcia), the last of which closed too close to submission for its findings to be incorporated into the analysis below; this will be addressed in a subsequent update. Rather than repeating that material, this subsection reflects specifically on the feedback most relevant to the risk evaluation carried out below.

Three themes from the interviews carry directly into the severity, urgency and capacity assessments in Sections 2.4.3–2.4.5. First, IMIDA's representative (Joaquín Francisco Atenza Juárez) and the DG IMAS interview (Francisco Honesto Castella Molina) both pointed to institutional coordination and the translation of diagnosis into applied policy as the area of greatest difficulty, with the incorporation of adaptation measures still at an early stage of implementation. Second, AMETSE's representative (Ginés Mirón Gallego) provided direct testimony on flash-flood response capacity in the Campo de Cartagena, including an explicit comparison with the October 2024 Valencia DANA, which informs the upward revision of river flooding's severity and urgency below. Third, the DG IMAS interview also raised a heat-specific concern – ageing and undersized climate-control equipment in residential and day-care centres for elderly and disabled users, compounded by slow procurement procedures – that is incorporated into the heatwave capacity assessment in Section 2.4.5. Interview evidence specific to coastal flooding is less extensive than for drought, river/pluvial flooding and heatwaves, but it is present in the ITREM and spatial-planning interviews, especially regarding tourism, coastal erosion, the Mar Menor and long-term land-use planning.

2.4.2 Gather output from Risk Analysis step

Risk evaluation in this subsection draws on two sets of Risk Analysis outputs from Section 2.3. For river and coastal floods (Section 2.3.2), Phase 2 carried out a quantitative deepening: a comparison of JRC versus CNIG hazard maps at the 10-, 100- and 500-year return periods (Table 2-25), and the resulting economic damage estimates under four hazard-map/exposure-layer combinations – JRC+LUISA, JRC+SIOSE, CNIG+LUISA and CNIG+SIOSE – benchmarked against Phase 1's own Phase 1 figures (Table 2-26). This deepening is comprehensive for both hazards, though structured differently: for river flooding, Phase 2 compares JRC against CNIG hazard maps under the same discrete return periods used in D1; for coastal flooding, Phase 2 replaces Phase 1's discrete-return-period GTSMv3.0 approach with new bathtub-model hazard modelling on a continuous 0–100 cm sea-level-rise sweep, paired with a validated vulnerability function and municipality-level damage estimates (Table 2-24). For agricultural drought (Section 2.3.1), Phase 2 provides revised workflow outputs based on regional crop-specific parameters, official production and price records, official crop surfaces and spatially explicit rainfed exposure data. These outputs replace the less coherent Phase 1 drought-loss estimates and are used in the KRA as the updated technical evidence for drought risk. For heatwave (Section 2.3.3), Phase 2 retains the Phase 1 quantitative outputs because this workflow did not show the same degree of methodological inconsistency detected for flood and drought. Stakeholder evidence is used to strengthen the interpretation of heatwave severity, urgency and resilience capacity.

In addition to these Section 2.3 outputs, the evaluation below also draws on Phase 1's own preliminary Key Risk Assessment (D1, Figure 2-27 and Sections 2.4.1–2.4.3) – its severity, urgency, capacity and priority ratings for all four hazards – as the explicit baseline against which Phase 2's findings are compared in Sections 2.4.3 to 2.4.6.

2.4.3 Assess Severity

REGMURCIA assessed severity for each of the four hazards using the same four-tier CLIMAAX scale applied in D1 – limited, moderate, substantial and critical – for both current and future risk. In Phase 2, this assessment is informed by the updated river and coastal flood evidence in Section 2.3.2 and, for all four hazards, by the stakeholder testimony gathered in eight of the nine interviews completed to date (Section 2.1.5).

The assessment below is organised hazard by hazard. Phase 1's rating for heatwave is carried forward without modification because the workflow was not quantitatively re-run in Phase 2 and did not show the same level of inconsistency identified for flood and drought. Agricultural drought, by contrast, is not simply carried forward: its critical severity is confirmed and strengthened by the updated Phase 2 drought workflow, which provides a more coherent regional expected-loss assessment for rainfed agriculture. River flooding's rating is revised in light of the new evidence in Section 2.3.2. Coastal flooding's rating is also carried forward, but not for lack of new evidence: Phase 2 produced substantial new coastal hazard and risk evidence (Section 2.3.2), yet Phase 1 provides no coastal euro-damage baseline against which to benchmark it, so the rating itself is retained pending that comparison.

- Agricultural drought (critical – confirmed and strengthened in Phase 2). D1 documented Segura Basin reservoir levels consistently among the lowest in Spain, agricultural losses above 40% for almonds and olives, and recurrent crises in citrus and horticultural crops across more than 100,000 ha of exposure, alongside a further 150,000+ ha of non-citrus fruit trees and cereals at risk. Phase 2 updates the drought workflow with regional crop, production, surface and rainfed-exposure evidence, producing a more coherent expected-loss assessment for rainfed agriculture. This confirms and strengthens the critical severity rating assigned in Phase 1, rather than merely carrying it forward. IMIDA's interview (Section 2.1.5) corroborates this qualitatively: its representative described crop vulnerability as resting on a "fragile equilibrium" (equilibrio frágil), contrasting the roughly three-month adaptive cycle of horticultural crops with the much longer, five-to-ten-year exposure window of fruit-tree plantations, which cannot be substituted quickly once a multi-year drought cycle sets in.
- River flooding (revised from substantial to critical). Phase 1's own preliminary assessment, based on JRC European flood hazard maps, already cautioned that this preliminary CRA should be viewed with caution in light of the significant discrepancy between current exposure data modelled by the CLIMAAX CRA and official flood mapping, and anticipated that incorporating national datasets in Phase 2 would likely see river flooding reclassified as Very High priority. The D2 deepening in Section 2.3.2 substantiates that expectation: CNIG national hazard maps show flooded areas 1.6 to 3.1 times larger than JRC's at the 10-, 100- and 500-year return periods, and the CNIG+SIOSE damage estimates (€1,593M / €5,708M /

€10,383M) are an order of magnitude above the JRC+SIOSE estimates Phase 1 relied on (€621M / €1,158M / €1,474M) – though, as discussed in Section 2.3.2, neither fully matches Phase 1's own independently-derived Phase 1 figures, a discrepancy that is analysed there rather than treated as resolved. AMETSE's testimony (Section 2.1.5) reinforces the upward revision qualitatively: the Campo de Cartagena is described by its representative as "un embudo" (a funnel) where intensive agriculture has flattened the terrain such that rainfall in Sucina can reach Los Alcázares in roughly twenty minutes, with an explicit comparison to the October 2024 Valencia DANA – "si se hubiera producido en Murcia los desastres hubieran sido tremendos" (had it occurred in Murcia, the disasters would have been tremendous).

- Coastal flooding (moderate; rating retained, evidence base substantially renewed in Phase 2). Phase 2 has now generated genuinely new coastal hazard and risk evidence, superseding the earlier, more limited exposure-layer-only comparison: a bathtub-with-hydraulic-connectivity model run continuously across the full 0–100 cm sea-level-rise range on a 5 m DEM, a vulnerability function validated against the September 2019 Los Alcázares flood, and municipality-level damage estimates (Section 2.3.2; University of Murcia collaboration). The new analysis identifies municipality-specific critical heights at which flooded area increases abruptly (approximately 37 cm and 65 cm of sea-level rise for San Pedro del Pinatar), a non-linear behaviour that Phase 1's coarser, discrete-return-period approach could not detect. This finding gives quantitative substance to Phase 1's own forward-looking caveat that today's 100-year storm surge could recur every 20–30 years by mid-century under +30–50 cm of sea-level rise, which D1 anticipated would elevate severity toward substantial-to-critical over time. Because D1 itself reports no coastal euro-damage baseline against which to benchmark Phase 2's new municipality-level figures (Section 2.3.2), the rating is retained at moderate for present-day conditions, pending Phase 3's fuller integration of these results. No interview to date has provided testimony specific to coastal flooding (Section 2.4.1).
- Heatwave (substantial-to-critical – carried forward from D1). Phase 1 documented record summers in 2022 and 2025, with maximum temperatures above 45°C and more than 20 heat-related fatalities in a single season, and projected 12–18 additional tropical nights per year by 2050 under SSP5-8.5. Phase 2 did not generate new AEMET or demographic exposure data for this hazard (Section 2.3.3), so this rating is carried forward rather than re-derived. The DG IMAS interview adds a relevant qualitative perspective: its representative described the users of residential and day-care centres for elderly people and people with disabilities as "usuarios muy vulnerables" (very vulnerable users) and identified climate-control (climatización) equipment failures – ageing units nearing the end of their service life, with no political-level plan for replacement – as a recurring problem in exactly the facilities where heat exposure is most consequential.

2.4.4 Assess Urgency

REGMURCIA assessed urgency for each of the four hazards using the same four-tier CLIMAAX scale applied in D1: no action needed, watching brief, more action needed, and immediate action needed. Phase 1's narrative descriptions for each hazard (D1, Section 2.4.2) did not assign these formal tiers explicitly; the labels used below make that mapping explicit for the first time, on the basis of Phase 1's own wording.

The assessment below follows the same hazard-by-hazard structure as Section 2.4.3, followed by two cross-cutting observations on speed of onset and on stakeholder perspectives that apply across all four hazards.

- Agricultural drought (immediate action needed). Phase 1 characterised drought as demanding continuous and escalating action: because its cumulative, slow-building impacts leave a narrowing window for effective adaptation, Phase 1 concluded that without immediate investment in water-use efficiency, irrigation governance and groundwater recovery, losses would become irreversible. Phase 2 did not generate new hydrological projections (Section 2.3.1), so this classification is carried forward unchanged.
- River flooding (revised to immediate action needed). Phase 1 described river flooding as a high-urgency hazard because extreme rainfall events develop suddenly and leave little reaction time, citing urbanisation of flood-prone areas and asset concentration in the Segura floodplain, though it stopped short of assigning this hazard the top formal urgency tier. The evidence gathered in Phase 2 supports moving it there: AMETSE's representative described local flash-flood response capacity in stark terms – "la capacidad de respuesta es muy poca y, como estamos hablando de [...] minutos" (response capacity is very limited, and we are talking about a matter of minutes) – and described the Paretón diversion channel, built at the end of the nineteenth century, as having left the basin "hiperregulada" (hyper-regulated) in ways that concentrate rather than disperse flows. Combined with the revised severity rating in Section 2.4.3, this points to immediate action needed rather than Phase 1's more qualified high-urgency framing.
- Coastal flooding (more action needed; rating retained, evidence base substantially renewed in Phase 2). D1 assessed coastal flooding as having low near-term urgency, since severe impacts are not expected until after mid-century, but stressed that strategic urgency remains high: adaptation planning, coastal-defence inventories and land-use controls need to be enacted now to avoid locking in future exposure. Phase 1 captured this as urgency that is deferred but inevitable. Phase 2's new continuous sea-level-rise modelling (Section 2.3.2) reinforces this characterisation with municipality-specific evidence: the critical heights identified for San Pedro del Pinatar (approximately 37 cm and 65 cm of sea-level rise) show that the timeline to abrupt impact is not uniform across the coast and, in at least some municipalities, may be reached well before the mid-century horizon Phase 1 had in mind. This sharpens, rather than overturns, Phase 1's deferred-but-inevitable framing: the urgency rating is retained, but Phase 3 should prioritise the municipalities where critical heights fall earliest within the plausible sea-level-rise range.
- Heatwave (immediate action needed). Phase 1 rated heatwaves as carrying immediate urgency, given their rapid onset and the more than 20 heat-related fatalities recorded in the 2025 season alone, and called for urgent action on public-health preparedness, labour protection and urban cooling. Phase 2 did not generate new exposure or mortality data for this hazard (Section 2.3.3), so this rating is carried forward unchanged.
- Speed of onset across hazards. Onset speed differentiates urgency across the four hazards. River flooding and heatwaves are sudden-onset hazards where the window between warning and impact is measured in minutes to hours, leaving little margin for reactive response and placing the emphasis on pre-positioned measures. Agricultural drought is a slow-onset,

cumulative hazard where urgency derives from a narrowing adaptation window rather than an imminent event. Coastal flooding combines a slow-onset driver (sea-level rise) with episodic storm-surge events, which is why its urgency is better understood as strategic and anticipatory rather than immediate. This distinction, rather than severity alone, explains why river flooding and heatwaves require operational readiness now, while drought and coastal flooding require sustained planning horizons.

- Stakeholder perspectives. Stakeholder testimony reinforces this urgency picture without contradicting it. AMETSE's representative situated current flash-flood vulnerability explicitly against the October 2024 Valencia DANA, warning that the Campo de Cartagena's funnel-like topography and hyper-regulated drainage network mean a comparable event could be at least as damaging locally. IMIDA's and DG IMAS's representatives, in turn, pointed less to the urgency of any single hazard than to a cross-cutting institutional bottleneck: both described the translation of risk diagnosis into applied, funded measures as slow relative to the pace at which the underlying hazards are evolving – a perspective that argues for treating institutional and procurement urgency as a complement to the hazard-specific ratings above, rather than as a separate category.

2.4.5 Understand Resilience Capacity

REGMURCIA assessed resilience capacity for each of the four hazards using the same four-tier CLIMAAX scale applied in Phase 1: low, medium, substantial, and high, considering financial, human, natural, physical and social dimensions of capacity. Phase 1's ratings for all four hazards are carried forward unchanged: Phase 2's quantitative deepening (Section 2.3.2) addressed hazard and exposure for river and coastal flooding, not adaptive or institutional capacity, so no hazard's capacity rating is revised here even though river flooding's severity and urgency are revised above. Where available, the eight completed stakeholder interviews are used to corroborate, rather than recalculate, Phase 1's capacity ratings.

- Agricultural drought (substantial-to-medium). Phase 1 found CARM to have substantial-to-medium capacity here: the region is globally recognised for advanced irrigation systems, desalination and wastewater reuse, providing a significant buffer against water scarcity. However, Phase 1 also noted that these measures are energy-intensive, costly, and insufficient to offset aquifer overdrafts and long-term structural water deficits, leaving natural capacity low and undermining resilience despite technological progress. Phase 2 did not generate new data on irrigation infrastructure or aquifer status (Section 2.3.1), so this rating is carried forward unchanged.
- River flooding (medium). Phase 1 rated river flooding capacity as medium: the basin benefits from SAIH monitoring, SNCZI flood maps and civil protection protocols, but gaps persist in drainage infrastructure, enforcement of floodplain zoning, and ecosystem-based buffers, so current measures reduce but do not neutralise high losses when extreme events occur. Phase 2's deepening (Section 2.3.2) addressed hazard and exposure, not response capacity, so this rating is carried forward unchanged even though severity and urgency are revised upward above. AMETSE's testimony, if anything, corroborates rather than improves this picture, describing the existing Paretón diversion channel as concentrating rather than mitigating flows.

- Coastal flooding (medium). Phase 1 rated coastal flooding capacity as medium: the PIMA Adapta-Murcia programme has improved hazard mapping and raised awareness, but full inventories of coastal defences are lacking and ecosystem-based adaptation remains underdeveloped; financial and technical resources are accessible, but institutional coordination is partial. Phase 2's coastal deepening (Section 2.3.2) substantially advanced the hazard and risk evidence base – new continuous sea-level-rise modelling, a validated vulnerability function, and municipality-level damage estimates – but did not itself address institutional or financial adaptive capacity, so this capacity rating specifically is carried forward unchanged. The new municipality-level results are, however, a directly actionable input for the hazard-mapping and planning work Phase 1 identified as already underway.
- Heatwave (medium-to-low). Phase 1 found CARM to have medium-to-low capacity for heatwaves: Spain operates robust meteorological alerts, and human and institutional expertise is strong, yet CARM lacks sufficient cooling shelters, social protection for vulnerable groups, and housing insulation to cope with persistent nocturnal heat, so social and infrastructural adaptation measures lag behind hazard intensification. The DG IMAS interview corroborates this gap directly for one of the region's most exposed populations: its representative described climate-control equipment in residential and day-care centres for elderly people and people with disabilities as ageing and failure-prone – "fue un desastre" (it was a disaster) in one documented episode – and identified slow procurement procedures and the absence of a political-level replacement plan as compounding factors. Phase 2 did not generate new quantitative capacity data for this hazard (Section 2.3.3), so Phase 1's medium-to-low rating is carried forward, with this stakeholder evidence added as qualitative corroboration.

2.4.6 Decide on Risk Priority

Following Phase 1's own approach (D1, Figure 2-27), REGMURCIA presents risk priority directly in this subsection as an in-text table rather than as a separately completed instance of the external evaluation dashboard referenced in the Key Risk Assessment Protocol. Table 2-28 below combines the severity, urgency and capacity ratings assigned in Sections 2.4.3 to 2.4.5 into an overall risk priority for each hazard, and sets Phase 2's priority alongside Phase 1's own Phase 1 priority for direct comparison.

Table 2-28 Comparison of Phase 1 (D1) and Phase 2 risk priority ratings, by hazard

Hazard	*Severity*	*Urgency*	*Capacity*	*Phase 1 Priority*	*Phase 2 Priority*
Agricultural drought	Critical	Immediate action needed	Substantial-to-medium	Very High	Very High (confirmed)
River flooding	Critical (revised from Substantial)	Immediate action needed (revised)	Medium	High	Very High (revised)
Coastal flooding	Moderate	More action needed	Medium	Moderate	Moderate (unchanged)
Heatwave	Substantial-to-critical	Immediate action needed	Medium-to-low	Very High	Very High (unchanged)

The headline change is river flooding's move from High (Phase 1) to Very High (Phase 2), driven by the revised severity and urgency ratings in Sections 2.4.3 and 2.4.4 above; its resilience capacity rating remains medium, unchanged from Phase 1. Heatwave retains Phase 1's priority, not because the risk is less relevant, but because the Phase 1 heatwave workflow did not show the same level of inconsistency identified for flood and drought and was therefore retained as the quantitative baseline (Section 2.3.3). Agricultural drought also remains Very High, but its rating is now supported by the updated Phase 2 drought workflow, which uses regional crop, production, surface and rainfed-exposure data to provide a more coherent expected-loss assessment for rainfed agriculture (Section 2.3.1). Coastal flooding retains its technical Phase 1 priority in Table 2-28 because Phase 1 provides no directly comparable coastal euro-damage baseline against which to benchmark the new Phase 2 municipality-level results. However, this technical rating is complemented by the stakeholder-based and integrated comparison in Sections 2.4.7 and 2.4.8, where coastal flooding and erosion are interpreted as a High strategic priority for coastal municipalities, tourism, the Mar Menor and future land-use planning. With this revision, agricultural drought, river/pluvial flooding and heatwave carry Very High priority in the technical KRA, while coastal flooding remains Moderate in the strictly comparable D1-D2 technical table but is treated as a High strategic priority in the integrated interpretation.

2.4.7 Stakeholder-based Key Risk Assessment

This section presents a stakeholder-based Key Risk Assessment derived from the quantitative survey and semi-structured interviews. It is designed as a perception- and governance-based assessment of severity, urgency, resilience capacity and overall risk priority for the main climate hazards considered in REGMURCIA CLIMAAX. The analysis does not replace the regionalized modelling results of the CLIMAAX workflows. Instead, it provides an independent stakeholder-evidence layer that is compared with the technical outputs in Section 2.4.8 and will be further validated with stakeholders during Phase 3.

The structure follows the logic of the preliminary Key Risk Assessment carried out in Phase 1, which classified droughts and heatwaves as very high priority hazards, river flooding as high, and coastal flooding as moderate, while noting that the integration of higher-resolution regional datasets during Phase 2 could modify this balance. The stakeholder-based assessment developed here is therefore particularly useful for identifying whether the perception of regional actors anticipates, confirms or qualifies the expected reclassification of risks when more detailed exposure, vulnerability and capacity information is incorporated.

2.4.7.1 Methodological approach

The scoring combines two complementary stakeholder-evidence streams. The survey provides a broad and comparable measure of perceived adaptation priority, concern and institutional capacity across 67 response records. The interviews provide a more detailed qualitative interpretation of risk severity, urgency, response capacity, barriers and sectoral impacts. To make both evidence streams comparable, the assessment uses a qualitative 0–3 scale consistent with the interview coding logic: 0 = not relevant or not identified, 1 = low or secondary, 2 = relevant/substantial, and 3 = very high or critical (Table 2-29).

Four dimensions were considered. Current severity reflects the perceived present importance of impacts already observed or operationally recognised by stakeholders. Future severity reflects the expected intensification, persistence or territorial expansion of these impacts. Urgency captures the perceived need for action in the short term, considering both rapid-onset hazards and slow-onset cumulative risks. Resilience capacity refers to the perceived ability of institutions, sectors and territories to anticipate, respond to and adapt to each risk. In the figure and tables below, a higher resilience-capacity score indicates stronger response capacity, while low or moderate scores indicate an implementation gap.

Table 2-29 Evidence streams and scoring logic used for the stakeholder-based Key Risk Assessment.

Dimension	*Main evidence used*	*Interpretation in this section*	*Scale*
Current severity	Interview severity coding; survey concern and hazard-specific adaptation priorities.	How serious the risk is perceived to be under current conditions.	0–3
Future severity	Interview expectations of future evolution; survey likelihood and concern items.	Expected intensification, persistence or expansion of impacts.	0–3
Urgency	Interview urgency coding; stakeholder priority assigned to adaptation measures.	Need for short-term or strategic action before risk becomes harder to manage.	0–3
Resilience capacity	Interview response-capacity coding; survey indicators on budget, training, monitoring, evaluation, information use and resilience.	Perceived capacity to anticipate, implement and sustain adaptation measures. Higher values indicate stronger capacity.	0–3
Risk priority	Synthesis of severity, future severity, urgency and capacity gap.	Qualitative priority for later comparison with workflow outputs and risk modelling.	Low / Moderate / High / Very high

2.4.7.2 Stakeholder-based risk ranking

The stakeholder-based Key Risk Assessment indicates substantial to critical severity and urgency for the main climate risks identified in REGMURCIA CLIMAAX. Agricultural droughts and heatwaves are perceived as critical both in current and future terms, while river flooding is considered substantial at present and critical in future and urgent terms. Coastal flooding and erosion are perceived as less transversal than the other hazards, but still substantial to critical in strategic and future terms, particularly for coastal planning, tourism and the Mar Menor. The main limiting factor identified by stakeholders is not low risk perception, but resilience capacity. Across the consultation, stakeholders repeatedly point to medium or medium-low response capacity due to coordination gaps, administrative delays, insufficient funding, lack of technical staff, uneven monitoring and difficulties in translating climate-risk evidence into implemented measures.

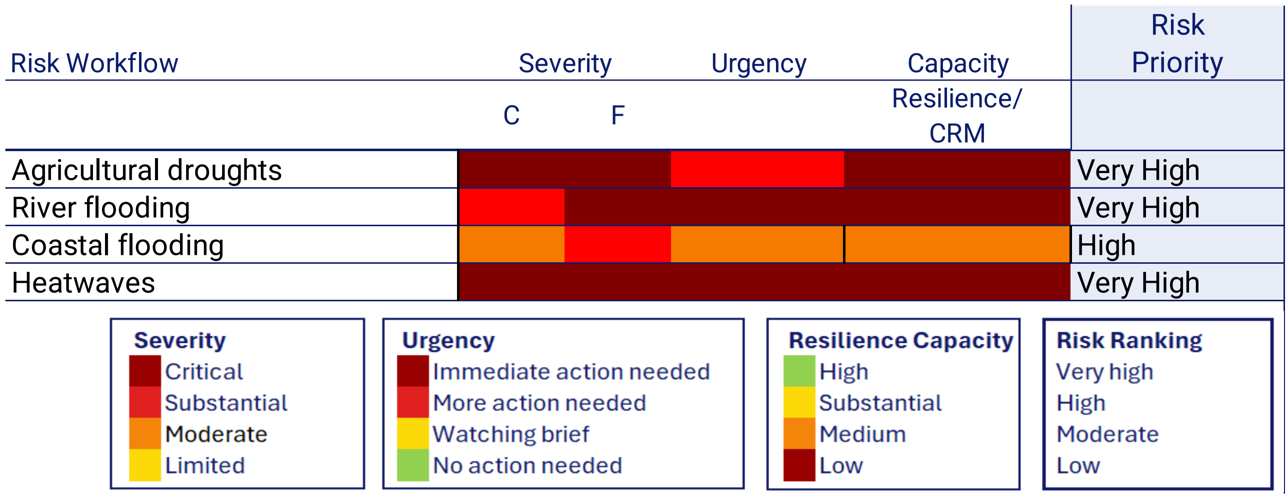

Figure 2-56 Stakeholder-based Key Risk Assessment for the Region of Murcia through risk ranking, considering current severity, future severity, urgency and resilience capacity. Source: REGMURCIA CLIMAAX stakeholder survey and interview coding.

Figure 2-56 shows a clear pattern: the hazards perceived as most severe and urgent are not necessarily those for which response capacity is strongest. Agricultural drought, rapid flooding and extreme heat all reach very high values for severity and urgency, but resilience capacity remains only moderate. This gap is central for the CLIMAAX assessment because it suggests that risk priority is driven not only by hazard intensity or exposure, but also by the ability of institutions and sectors to implement adaptation measures in time.

2.4.7.3 Severity

From the stakeholder perspective, agricultural drought remains a very severe risk because it is not perceived only as a meteorological anomaly or a water-deficit indicator. Survey respondents assigned very high importance to water saving, treated wastewater reuse, soil-moisture conservation, aquifer and wetland protection, and limits on water-intensive expansion. Interviews further specify that drought affects dryland productivity, crop yields, agricultural insurance, extensive livestock, abandonment, erosion and generational renewal. This reinforces the interpretation of drought as a socioeconomic and territorial risk, particularly in dryland systems where adaptive margins are lower.

River and pluvial flooding also reach very high perceived severity. Stakeholders repeatedly link flood impacts with torrential rainfall, ephemeral streams, exposed land uses, flood-prone areas, drainage, early-warning capacity and territorial planning. The survey reinforces this by giving high scores to restoration of riverbanks and natural channels, avoidance of new construction in high-risk areas, early-warning systems and revision of urban planning. This pattern is important because it supports a broader interpretation of flooding as a territorial and governance risk, not only as a hydrological footprint.

Heatwaves are perceived as a severe and increasingly multi-sectoral risk. The survey gives the highest average adaptation-priority score to heatwave measures, especially trees, shade, blue-green spaces, protection of vulnerable groups, building adaptation and urban heat-island reduction. The interviews add a functional dimension by linking heat to care homes, schools, public facilities, outdoor work, tourism, agriculture, energy demand and urban liveability. Coastal flooding and erosion show lower overall salience than the other three hazards, but the stakeholder evidence still points to relevant severity in exposed coastal areas, tourism destinations, the Mar Menor context and coastal-planning decisions.

2.4.7.4 Urgency

Urgency is high for drought, flooding and heat, although the temporal logic differs between them. Drought is a slow-onset and cumulative risk, but stakeholders describe it as urgent because delayed adaptation can make losses irreversible through abandonment, erosion, aquifer degradation and loss of agricultural viability. The urgency is therefore not associated with sudden onset, but with the narrowing window for effective long-term adaptation.

Flooding and heatwaves involve a more immediate form of urgency. Torrential rainfall and rapid flooding can develop with short warning times, especially in ephemeral streams and small catchments. Stakeholders emphasise the need for preventive planning, monitoring, maintenance, alert systems and local communication. Heatwaves also require immediate preparedness because their effects on vulnerable groups, buildings, outdoor work and public services occur during short but increasingly frequent episodes. Coastal flooding and erosion present a more strategic urgency: impacts may be spatially concentrated and, in some cases, longer-term, but current planning decisions can lock in future exposure if coastal development, infrastructure and tourism pressure are not managed preventively.

2.4.7.5 Resilience capacity

The most important result of the stakeholder-based assessment is the gap between high perceived priority and only moderate resilience capacity. Survey results show limited dedicated adaptation budgets, uneven training, low monitoring and evaluation scores, and only moderate use of climate-risk maps and technical analyses outside specific domains such as river flooding. Interviews confirm this implementation gap by repeatedly identifying institutional fragmentation, administrative slowness, insufficient funding, competence conflicts, short political cycles, lack of technical staff and limited citizen participation.

For drought, existing capacities such as irrigation efficiency, treated wastewater reuse, desalination, agricultural knowledge and agroclimatic monitoring are recognised, but stakeholders still perceive them as insufficient to address structural water scarcity, dryland viability and long-term territorial degradation. For flooding, the existence of flood maps, civil-protection experience, warning systems and hydrological monitoring does not fully compensate for exposed land uses, insufficient enforcement of planning restrictions and the need for more localised early-warning information. For heatwaves, meteorological alerts exist, but the stakeholder evidence points to weaker capacity in cooling shelters, climate-proofing of public buildings, protection of vulnerable groups, labour adaptation and urban cooling. Coastal capacity is also moderate, with needs related to integrated planning, ecosystem-based protection, inventories, coastal defence assessment and coordination between tourism, territorial planning and environmental management.

2.4.7.6 Stakeholder-based risk priority and comparison with Phase 1

The stakeholder-based assessment broadly confirms the main risk areas identified during Phase 1, but it modifies their relative interpretation. Agricultural drought remains a very high priority from the stakeholder perspective, especially because interviews place strong emphasis on dryland viability, abandonment, insurance, erosion and generational renewal. This is relevant because the preliminary Phase 1 assessment anticipated that more detailed exposure and vulnerability data could potentially downgrade agricultural drought from very high to high; Phase 2 began assembling part of that evidence base (Section 2.3.1), though without yet recalculating the headline classification from it. Stakeholder evidence suggests that any future technical reclassification should still preserve the structural territorial importance of dryland systems.

River flooding is the risk for which stakeholder evidence most clearly reinforces an upward reassessment. In the preliminary Phase 1 Key Risk Assessment it was classified as high, with the expectation that higher-resolution datasets could lead to a very high classification. The stakeholder assessment supports this expectation: interviews and survey responses consistently point to torrential rainfall, ephemeral streams, land occupation, planning deficits, exposed infrastructure, warning time and governance capacity as key drivers of actual risk.

Heatwaves are also confirmed as very high priority. The stakeholder contribution is especially useful because it expands the interpretation of heat beyond temperature indicators and mortality. Heat is framed as a social, urban, labour, infrastructural, agricultural and tourism-related risk. Coastal flooding remains less transversal than drought, heat and rapid flooding, but stakeholder evidence suggests that it should be treated as high and spatially concentrated rather than moderate in purely strategic terms, especially where coastal tourism, erosion, Mar Menor dynamics and planning decisions interact.

2.4.8 Integrated comparison of D1, Phase 2 workflows and stakeholder-based risk priority

This subsection adds an explicit triangulation layer to the Key Risk Assessment. Its purpose is to compare the preliminary Phase 1 risk-priority assessment, the refined Phase 2 workflow evidence and the stakeholder-based assessment derived from surveys and interviews. This comparison is important because the three evidence streams do not perform the same function. The Phase 1 assessment provided the initial screening and prioritisation; the Phase 2 workflows refine the technical evidence using local and national datasets where available; and the stakeholder-based assessment captures perceived severity, urgency, implementation capacity and institutional feasibility.

The comparison should therefore be interpreted as an integrated decision-support exercise rather than as a purely numerical recalculation. Agreement between the three evidence streams increases confidence in the priority assigned to a risk. Divergence does not necessarily indicate error; it helps identify where additional data, further explanation, stakeholder validation or governance measures are needed before adaptation priorities are closed in Phase 3.

2.4.8.1 Harmonised scoring logic

To compare the three evidence streams, the qualitative categories used in the CLIMAAX Key Risk Assessment were harmonised into a four-level scale. For severity, the scale ranges from limited to critical. For urgency, it ranges from no action needed to immediate action needed. For resilience capacity, it ranges from low to high, where higher values indicate stronger capacity. For risk priority, it ranges from low to very high. Intermediate labels already used in the report, such as substantial-to-critical or medium-to-low, were converted to midpoint values only for visualisation purposes; the original qualitative interpretation remains the basis for the text (Table 2-30).

Table 2-30 Evidence streams used for the integrated comparison of risk priority

Evidence stream	*Role in comparison*	*Main contribution*	*Main limitation*
D1 preliminary KRA	Baseline reference	Initial CLIMAAX-based prioritisation: droughts and heatwaves very high, river flooding high, coastal flooding moderate.	Based on coarser European-scale data and preliminary exposure/vulnerability assumptions.
D2 workflow-refined evidence	Technical refinement	Improves river and coastal flood evidence; deepens drought exposure and vulnerability; carries heatwave forward from D1.	Coastal comparison with D1 lacks a comparable euro-damage baseline.
Stakeholder-based KRA	Perception and governance layer	Adds evidence on observed impacts, perceived urgency, implementation barriers, response capacity and adaptation feasibility.	Not statistically representative; reflects consulted stakeholders and must be triangulated with modelled results.

2.4.8.2 Cross-evidence comparison of risk priority

The integrated comparison shows that the overall direction of the assessment is highly coherent (Figure 2-57). Agricultural drought and heatwaves remain very high-priority risks in all evidence streams. River flooding shows the clearest upward correction from Phase 1 to Phase 2: it moves from high priority in the preliminary assessment to very high priority once national hazard data, refined exposure comparison and stakeholder evidence are considered. Coastal flooding and erosion show the main interpretative divergence. Phase 1 classified coastal flooding as moderate, partly because its impacts were treated as more localised and because no comparable economic-damage baseline was available. Phase 2 coastal modelling and the stakeholder evidence both indicate a stronger strategic signal: while present-day coastal risk may remain spatially concentrated, future sea-level rise, non-linear local thresholds, tourism exposure and Mar Menor-related pressures justify treating it as at least a high strategic priority for adaptation planning.

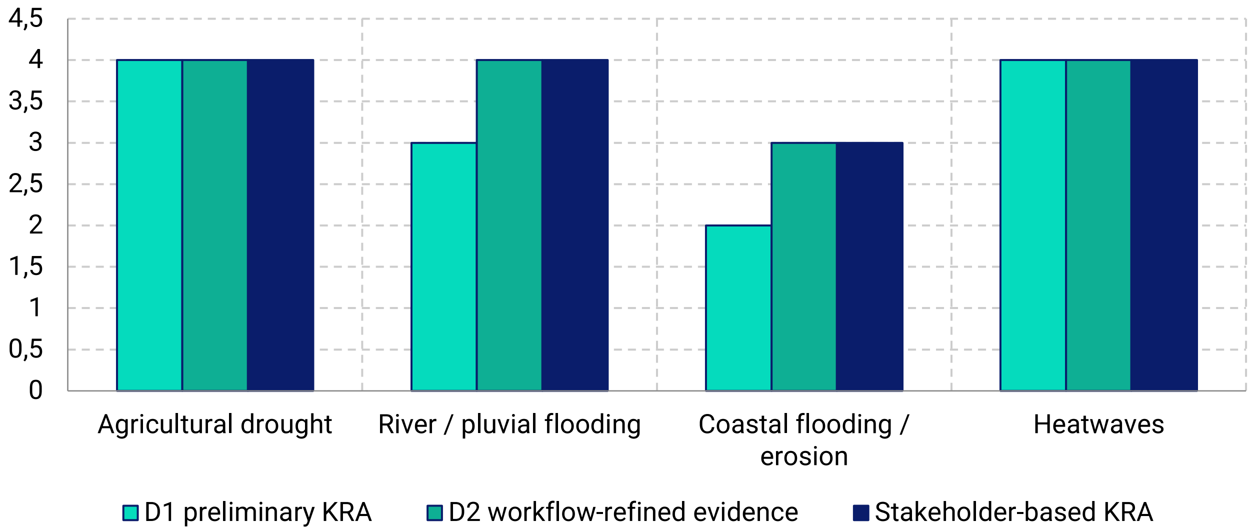

Figure 2-57 Integrated comparison of risk-priority ratings across D1, Phase 2 workflow-refined evidence and the stakeholder-based assessment. Source: REGMURCIA CLIMAAX, based on D1, D2 workflow results, survey results and interview coding.

The most robust agreement concerns drought and heatwaves, which are consistently placed at the highest priority level. For drought, the agreement is driven by the structural role of water scarcity in the regional economy and by the territorial vulnerability of dryland agriculture. For heatwaves, the agreement is driven by high present and future severity, rapid intensification and the exposure of vulnerable groups, buildings, labour conditions and urban systems. River flooding is the most important change relative to Phase 1: the technical evidence and stakeholder evidence converge in supporting its reclassification as very high priority. Coastal flooding is the only case where the comparison requires a more careful distinction between present-day conservative scoring and future strategic priority (Table 2-31).

Table 2-31 Integrated comparison of risk-priority ratings and interpretation by hazard.

Hazard	*D1 preliminary priority*	*D2 workflow-refined signal*	*Stakeholder-based priority*	*Integrated interpretation*
Agricultural drought	Very high	Very high	Very high	Full agreement. Keep as very high; prioritise drought/agriculture adaptation and extend the Phase 2 recalculation (Section 2.3.1) from the illustrative almond case to a fully costed, stakeholder-validated assessment across all seven rainfed crops in Phase 3.
River / pluvial flooding	High	Very high	Very high	Convergent upward revision. Reclassify as very high due to CNIG/SIOSE evidence, short warning times, territorial exposure and governance barriers.
Coastal flooding / erosion	Moderate	High strategic signal	High	Partial divergence. Present-day risk is more localised, but future modelling and stakeholders support high strategic priority, especially for coastal

				planning, tourism and Mar Menor areas.
Heatwaves	Very high	Very high	Very high	Full agreement. Keep as very high; the main issue is response capacity rather than risk recognition.

2.4.8.3 Severity, urgency and resilience-capacity comparison

The dimensional comparison confirms that stakeholder evidence does not reduce the perceived importance of the main risks. On the contrary, stakeholders tend to reinforce substantial-to-critical severity and high urgency for drought, river/pluvial flooding and heatwaves. The main difference appears in resilience capacity: stakeholders repeatedly identify medium or medium-low capacity to translate risk knowledge into implemented measures. This is consistent with the survey findings on budgets, staff training, monitoring and evaluation, and with the interview evidence on institutional coordination, administrative slowness, insufficient funding, lack of technical staff and difficulties in making climate-risk outputs operational (Figure 2-58).

	Current severity	Future severity	Urgency	Resilience capacity	Risk priority
Agricultural drought-D1 preliminary KRA	4	4	4	2,5	4
Agricultural drought-D2 workflow-refined evidence	4	4	4	2,5	4
Agricultural drought-Stakeholder-based KRA	4	4	4	1,8	4
River / pluvial flooding-D1 preliminary KRA	3	3	3	2	3
River / pluvial flooding-D2 workflow-refined evidence	4	4	4	2	4
River / pluvial flooding-Stakeholder-based KRA	3,5	4	4	1,8	4
Coastal flooding / erosion-D1 preliminary KRA	2	3	2,5	2	2
Coastal flooding / erosion-D2 workflow-refined evidence	2,5	3,5	3	2	3
Coastal flooding / erosion-Stakeholder-based KRA	3	4	3	2	3
Heatwaves-D1 preliminary KRA	3,5	4	4	1,5	4
Heatwaves-D2 workflow-refined evidence	3,5	4	4	1,5	4
Heatwaves-Stakeholder-based KRA	4	4	4	1,8	4

Severity
Critical
Substantial
Moderate
Limited

Urgency
Immediate action needed
More action needed
Watching brief
No action needed

Resilience Capacity
High
Substantial
Medium
Low

Risk Ranking
Very high
High
Moderate
Low

Figure 2-58 Harmonised comparison of current severity, future severity, urgency, resilience capacity and risk priority across evidence streams. Higher capacity values indicate stronger response capacity. Source: REGMURCIA CLIMAAX.

This comparison has two implications for the final Climate Risk Assessment. First, risk priority should not be interpreted only as a function of modelled hazard intensity or expected damage. In several cases, especially heatwaves and river/pluvial flooding, the urgency of action is amplified by the limited capacity to implement preventive measures at the necessary speed. Second, the comparison shows that the stakeholder-based assessment is not an alternative to the workflow results, but a complementary validation and interpretation layer. It helps explain why certain risks require immediate action even where some technical outputs remain incomplete or conservative.

2.4.8.4 Agreements, divergences and implications for implementation

The integrated assessment identifies three types of outcome. The first is strong convergence, where D1, Phase 2 workflows and stakeholders point in the same direction. This applies to agricultural drought and heatwaves. The second is evidence-based upward revision, where Phase 2 confirms an expected change from D1. This applies to river/pluvial flooding. The third is strategic divergence, where the technical evidence and stakeholder perception suggest a higher adaptation priority than the conservative formal rating inherited from Phase 1. This applies to coastal flooding and erosion (Table 2-32).

Table 2-32 Agreements, divergences and implementation opportunities derived from the integrated comparison.

Finding	*Hazards concerned*	*Meaning for Phase 3*	*Potential implementation agreement*
Full convergence	Agricultural drought; heatwaves	Use as stable priorities for adaptation co-design.	Develop no-regret packages on water efficiency, dryland support, heat-health protection, urban shade and public-building climate-proofing.
Upward revision confirmed	River / pluvial flooding	Treat as very high priority in the final KRA and adaptation pathway.	Agree on early warning, floodplain planning, drainage maintenance, riverbank/natural-channel restoration and municipal risk factsheets.
Strategic divergence requiring clarification	Coastal flooding / erosion	Clarify whether the final D2 priority remains conservative/moderate or is upgraded to high strategic priority based on Phase 2 modelling and stakeholder evidence.	Prioritise coastal planning review, dune/wetland restoration, Mar Menor-compatible management and avoidance of new exposure.
Capacity gap across hazards	All hazards	Address implementation capacity as a risk amplifier.	Create cross-cutting agreements on inter-administrative coordination, funding continuity, staff training, interoperable data and monitoring/evaluation indicators.

The integrated comparison therefore supports a practical conclusion for Phase 3: the Region of Murcia should not wait for a single perfectly resolved ranking before discussing adaptation measures. For drought, river/pluvial flooding and heatwaves, the level of agreement is already sufficient to begin co-designing adaptation pathways. For coastal flooding and erosion, the priority should be framed as high strategic priority for territorial planning, even if the present-day formal score is kept more conservative. Across all hazards, the strongest shared implementation agenda concerns enabling conditions: coordination between administrations, stable funding, technical staff capacity, operational data products, early-warning systems, monitoring and evaluation, and communication tools that can be used by municipalities, sectoral bodies and exposed communities.

2.5 Monitoring and Evaluation

Key lessons. The main lesson from Phase 2 is methodological: comparing European (JRC hazard maps, LUISA land use) and Spanish national (CNIG hazard maps, SIOSE land use) data sources for the same hazard, river and coastal flooding, produces materially different damage estimates even when scenario assumptions are held constant (Section 2.3.2). The greatest difficulty was reconciling these divergent inputs and explaining, rather than simply reporting, why the resulting risk priority for river flooding changes between data sources (Section 2.4.6). This reinforced the need to document data provenance explicitly and to treat any single damage estimate as conditional on its underlying hazard and exposure data, not as a single ground truth.

Stakeholder role and feedback. Of the nine stakeholder interviews planned for this phase, all nine have been completed at the time of writing (IMIDA, DG IMAS, DG Industria Alimentaria y Asociacionismo Agrario, Dirección General de Ordenación del Territorio y Arquitectura, FECOAM, AMETSE, the Local Energy and Climate Change Agency of Ayuntamiento de Murcia, ITREM, and Ecologistas en Acción Región de Murcia). Feedback so far converges on two points. First, interviewees consider results genuinely useful only if they avoid duplicating or conflicting with existing official sources. Second, several interviewees (AMETSE, the Ayuntamiento de Murcia agency) stressed that technical results only translate into policy outcomes when they are framed as actionable instruments tied to a specific decision-maker's priorities, rather than left as purely scientific output. ITREM's feedback is sector-specific: heatwave and drought projections are more relevant to tourism than flooding, and findings will feed into the sector's ongoing social-sustainability awareness strategy.

Is learning ensured? Within Phase 2, learning has occurred mainly through the technical meetings between UMU and the CARM and through the stakeholder interviews summarised above, rather than through a separately documented institutional review process. Whether a more formal learning loop – e.g., a standing review or lessons-log mechanism – exists or is planned beyond these channels has not been confirmed at the time of writing and should be clarified with the CARM project team before the next reporting cycle.

Data availability and remaining needs. New data became available in Phase 2 for river and coastal flooding (Section 2.3.2) and, on the exposure and vulnerability side, for agricultural drought (Section 2.3.1); heatwave risk alone is carried forward from D1 without new quantitative input (Section 2.3.3). Beyond completing the one outstanding stakeholder interview, the main remaining needs identified are: extending the revised drought yield-loss estimates from the illustrative almond case (Section 2.3.1) to a fully costed, stakeholder-validated assessment across all seven rainfed crops; demographic projections by age band to replace the stationary 2020 population rasters used for heatwave vulnerability (a limitation already flagged in D1); a reconciled, authoritative choice between the European and Spanish national hazard/exposure datasets compared in Section 2.3.2, rather than carrying both forward in parallel; and updated irrigation-infrastructure and aquifer-status data, without which the agricultural drought capacity rating cannot be revised.

Communicating outcomes. Stakeholder feedback points toward a tiered communication approach: technical, GIS-based outputs (risk maps, downloadable data layers) for specialist institutional users; plain-language municipal and sectoral fact sheets for local government and sectoral bodies; and, following IMIDA's specific recommendation, a simplified citizen-facing viewer that would let a resident check flood risk for a given cadastral reference without needing to interpret technical concepts such as return period. AMETSE's feedback reinforces that, whichever format is chosen, outcomes need to be framed as concrete, actionable instruments usable by local decision-makers, not left as technical/scientific output alone.

Monitoring system. The CARM's Regional Strategy for Mitigation and Adaptation to Climate Change (ERMACC, CARM 2019) and its associated Regional Observatory for Climate Change – a participatory body involving AEMET, the Confederación Hidrográfica del Segura, the Coastal

Authority, businesses and civil society – constitute the existing framework within which the risks analysed here are tracked. This is a strategic and participatory framework rather than a dedicated technical system for monitoring risk indicators specifically; REGMURCIA's outputs are intended to feed into it rather than replace it.

What worked, what did not. Comparing multiple hazard and exposure data sources for river and coastal flooding (Section 2.3.2) worked well as a way of testing the robustness of Phase 1's risk priority and of surfacing a methodologically grounded explanation for why it changes (Section 2.4.6). Agricultural drought advanced substantially in this phase: Phase 2 combined new crop-specific exposure and vulnerability evidence with Phase 1's hazard projections (Section 2.3.1), yielding revised yield-loss estimates for rainfed agriculture and a corrected economic-loss estimate for almond, in place of Phase 1's internally inconsistent headline figures. Heatwave risk did not advance at all in this phase, by design (Section 2.1.2): no new quantitative work was carried out for this hazard, so Phase 1's findings stand unchanged. On stakeholder engagement, all nine planned interviews were completed within the reporting period; the most recently completed, with Ecologistas en Acción Región de Murcia, closed too close to submission for its input to be incorporated into the analysis above, and this will be addressed in a subsequent update.

Resource use. Phase 2 was carried out by the same small UMU team responsible for Phase 1, working within the project's overall Phase 2 timeframe (Months 7–16) and combining the hazard/exposure data comparison (Section 2.3.2) with the stakeholder interview round (Section 2.5). No formal time- or cost-tracking system was applied at the task level, so this cannot be quantified in hours or budget here; qualitatively, the main resource-allocation choice was to concentrate the quantitative deepening on a single hazard, river and coastal flooding, rather than spreading new analysis across all four hazards, consistent with the scope decision in Section 2.1.2.

Effect on the CRA process. Concentrating most of Phase 2's quantitative effort on river and coastal flooding allowed a more thorough, multi-source comparison for that hazard (Section 2.3.2) than would have been possible had effort been spread thinly across all four hazards; the trade-off is that agricultural drought's deepening, while it did produce revised yield-loss and economic-loss estimates (Section 2.3.1), remains illustrated mainly through the almond case rather than fully costed across all seven rainfed crops, and heatwave risk did not benefit from any new scrutiny in this phase. Whether this allocation was efficient overall depends on a resource-tracking baseline that, as noted above, does not currently exist.

Value of the CRA. Stakeholder feedback suggests the CRA's impact to date is mainly on institutional capacity and decision-support potential rather than yet on funding or investment: IMIDA highlighted its usefulness for prioritising measures and avoiding duplication with existing official sources, AMETSE framed it as a potential basis for concrete local-government decisions, and ITREM expects it to feed into a sectoral strategic plan. Public-awareness impact appears more limited so far, since pre-existing awareness of flooding and drought among the stakeholders interviewed (e.g., the Ayuntamiento de Murcia agency's account of 1990s water-supply restrictions) predates this CRA; whether the CRA itself shifts broader public awareness or unlocks new funding remains to be seen once outcomes are disseminated in Phase 3.

2.6 Work plan Phase 3

Phase 3 (Months 17–22) will focus on the participatory exploration of adaptation options, building on the risk priorities established in Section 2.4.6. Planned activities include: participatory workshops with stakeholders, including the nine entities engaged in Phase 2 (Section 2.1.5), to co-design adaptation measures for the four hazards in REGMURCIA's portfolio; development of a catalogue of adaptation measures; and preparation of a summary document with actionable steps and sectoral plans, including prioritised measures, timelines, responsibilities and budgets, designed for integration into existing planning and regulatory frameworks, including the ERMACC and local general plans. Phase 3 will conclude with final dissemination activities, including publication of results and participation in the closing CLIMAAX workshop in Brussels. Phase 3 will not involve the physical implementation of adaptation measures or the drafting of legislative texts; these fall outside REGMURCIA's scope under the FSTP cascade-grant mechanism.

3 Conclusions Phase 2- Climate risk assessment

Phase 2 deepened the climate risk assessment established in Phase 1 for the Region of Murcia, concentrating new quantitative analysis on river and coastal flooding, updating the agricultural-drought workflow with regional crop-specific parameters, official production and price records, crop-surface data and spatially explicit rainfed agricultural exposure, producing revised yield-loss outputs and a corrected economic-loss estimate illustrated for almond. All nine planned stakeholder interviews were completed, together with a 67-response survey, adding an independent perception- and governance-based layer to the regionalised modelling.

For river and coastal flooding, Phase 2's central contribution was a like-for-like comparison between the European default data pipeline used in Phase 1 (JRC hazard maps, LUISA land use) and Spain's official national sources (CNIG/SNCZI hazard maps, SIOSE land use), complemented for the coast by a new continuous sea-level-rise model. The river comparison confirmed and quantified the hazard-data discrepancy Phase 1 had only flagged qualitatively: national sources show substantially larger flooded areas, and the choice of hazard-map source alone can change river-flood damage estimates by an order of magnitude — identified as the dominant driver of Phase 2's sensitivity analysis (Section 2.4.6) – evidence that supported revising river flooding's risk priority from High (Phase 1) to Very High (Phase 2), while its resilience-capacity rating remains medium, unchanged from Phase 1. The coastal model, validated against the September 2019 Los Alcázares flood and disaggregated to municipality level for the first time, identifies Cartagena and San Javier as the highest-loss locations; because Phase 1 reports no comparable coastal damage baseline, this new evidence cannot yet be benchmarked against Phase 1, so coastal flooding's risk priority is retained at Moderate pending that comparison.

Agricultural drought received a substantial methodological update in this phase. The Phase 2 workflow replaces the generic global exposure and vulnerability assumptions used in Phase 1 with FAO-56 dual crop-coefficient parameters for seven dryland crops, ESAM-sourced production and price data, and a SIGPAC/CREM-derived spatial exposure layer. This update produces revised yield-loss estimates for rainfed agriculture and a corrected economic-loss estimate illustrated for almond, while also documenting the internal inconsistencies in Phase 1's drought-loss figures. Remaining work concerns validation, local calibration and extension of the economic valuation, rather than producing the first revised drought assessment. Heatwave was not deepened with new hazard or exposure data at all in this phase, per the scope agreed for Phase 2. Both hazards' risk ratings are Very High priority. For heatwave, Phase 1 projects annual frequency rising from around 3 events per year at baseline to over 50 events per year by late century under RCP8.5 — roughly a tenfold increase — with interior areas of the region seeing an approximately 10-fold rise and the southern coastal belt an approximately 8-fold rise; 22 heat-related deaths were recorded in Murcia in summer 2025 alone, more than double the 2024 figure. Stakeholder testimony gathered in Phase 2 corroborates both hazards qualitatively, including the DG IMAS interview's identification of ageing, failure-prone climate-control equipment in social-care facilities as a recurring risk for the region's most heat-vulnerable residents.

The stakeholder-based Key Risk Assessment, new in this phase and drawn from 67 survey responses and eight of the nine completed interviews, broadly confirms these technical findings while adding one qualification: coastal flooding, though less transversal than the other three hazards, is rated High by stakeholders – above its Moderate technical rating – reflecting concerns specific to coastal tourism, erosion and the Mar Menor. Across all four hazards, the main limiting factor identified by stakeholders is not low risk perception but resilience capacity, driven by coordination gaps, administrative delays, insufficient funding and limited technical staff.

In summary, Phase 2 confirms that all four hazards in REGMURCIA's portfolio carry substantial to very high risk, though the strength of evidence behind each rating differs markedly:

- River flooding risk has been revised upward to Very High, the headline technical change of this phase, on the strength of a quantified hazard-data discrepancy between European and Spanish national sources rather than a change in resilience capacity, which remains medium in both phases.
- Coastal flooding risk priority remains Moderate in the strictly comparable technical D1-D2 table because Phase 1 did not provide a directly comparable coastal euro-damage baseline. However, Phase 2 delivered the region's first disaggregated, validated, municipality-level coastal damage assessment, and stakeholder evidence supports treating coastal flooding and erosion as a High strategic priority for coastal municipalities, tourism, the Mar Menor and long-term land-use planning.
- Agricultural drought risk remains Very High, but the rating is no longer based only on the Phase 1 workflow. Phase 2 strengthens this result through an updated drought workflow based on regional crop-specific parameters, official production and price records, official crop surfaces and spatially explicit rainfed agricultural exposure. The resulting expected-loss assessment for rainfed agriculture is more coherent than the Phase 1 output and is independently corroborated by stakeholder testimony and survey evidence.
- Heatwave risk remains Very High, with the Phase 1 quantitative workflow retained because it did not show the same level of inconsistency or data-source divergence identified for flood and drought. Phase 2 strengthens this interpretation through stakeholder testimony and survey evidence.
- Resilience capacity, not hazard severity or stakeholder concern, is the principal constraint identified across all four hazards, driven by institutional coordination gaps, administrative delays and resource limitations rather than a lack of awareness.

These findings support the risk prioritisation set out in Section 2.4.6 and reinforce the urgency of targeted adaptation action, particularly for river flooding and heatwave. Phase 3 (Months 17–22) will build on these results through participatory workshops with the stakeholder entities engaged in this phase, a catalogue of adaptation measures, and a summary document for integration into the ERMACC and local planning frameworks. Phase 3 should also resolve the methodological and implementation questions that remain open: reconciling the JRC/CNIG flood-damage gap, incorporating the Ecologistas en Acción interview's findings, validating and operationalising the revised agricultural-drought results with sectoral stakeholders, and further strengthening the heatwave workflow with local social, demographic, public-health and facility-level evidence.

The results of Phase 2 also indicate that adaptation should move from general diagnosis to agreement-building. Sectoral technical working tables should be used in Phase 3 to translate the integrated KRA into feasible adaptation pathways for rainfed agriculture, river/pluvial flooding and spatial planning, coastal flooding and tourism/Mar Menor governance, heatwaves and vulnerable public facilities, and cross-cutting data, monitoring and governance systems.

4 Progress evaluation

This deliverable marks the successful completion of Phase 2 of the REGMURCIA CLIMAAX project (Table 4-1 and Table 4-2), which focused on deepening the Phase 1 climate risk assessment for the Region of Murcia through refined flood analysis, an updated agricultural-drought workflow with revised expected-loss estimates for rainfed agriculture, and a substantially broadened stakeholder engagement process. The outputs produced during this phase lay the basis for the participatory, adaptation-focused work planned for Phase 3. The present deliverable has met all objectives defined for this stage of implementation under the Individual Follow-up Plan: three Technical meetings (M7, M10, M13), the Participatory workshop (M16), and the submission of this Deliverable 2 (M16).

Through the continued application of the CLIMAAX Common Methodology, the Region of Murcia has compared, for river and coastal flooding, the European default data pipeline used in Phase 1 (JRC hazard maps, LUISA land use) against Spain's official national sources (CNIG/SNCZI hazard maps, SIOSE land use), complemented for the coast by a new, validated sea-level-rise model. This work quantified, for the first time, the hazard-data discrepancy Phase 1 had only flagged qualitatively, and supported revising river flooding's risk priority to Very High. In parallel, agricultural drought received a deepening of its exposure and vulnerability evidence base (a FAO-56 crop-coefficient parameterisation, ESAM production and price data, and a SIGPAC/CREM exposure layer), and all four hazards in the region's portfolio were re-examined through completed stakeholder interviews and a 67-response survey. These findings have been summarised against the CLIMAAX framework criteria in Section 3 and will guide the focus of the adaptation-measure design planned for Phase 3.

In terms of project integration, this deliverable ensures continuity with Phase 3 by: (1) quantifying the European-versus-national hazard-data discrepancy for river flooding and revising its risk priority accordingly; (2) delivering the region's first disaggregated, validated, municipality-level coastal flood damage assessment, ready for benchmarking once a comparable Phase 1 baseline exists; (3) combining an expanded agricultural-drought exposure and vulnerability evidence base with Phase 1's hazard projections into revised yield-loss estimates for rainfed agriculture, with a corrected economic-loss estimate illustrated for almond (Section 2.3.1); (4) substantially broadening the stakeholder base consulted across all four hazards, which forms the starting point for the Phase 3 participatory workshops on adaptation-measure co-design (Section 2.6); and (5) flagging the methodological items Phase 3 should resolve.

These outputs will be revisited and built upon through the participatory workshops, adaptation-measures catalogue, and summary document planned for Phase 3 (Months 17–22, Section 2.6), and the technical-meeting channel established between UMU and CARM is expected to continue supporting the methodological reconciliation flagged above. This document thus serves as both a progress record against the Individual Follow-up Plan and a working basis for the next phase of the REGMURCIA CLIMAAX roadmap.

Table 4-1 Overview key performance indicators

Key performance indicators	*Progress*
Number of workflows applied/deepened in Deliverable 2	Achieved. The river and coastal flooding workflow was deepened through a systematic comparison of European (JRC hazard maps, LUISA land use) and Spanish national (CNIG/SNCZI hazard maps, SIOSE land use) data sources, including DamageScanner-based damage estimation across the 10-, 100- and 500-year return periods (Section 2.3.2). The agricultural drought workflow was deepened with a new FAO-56 crop-specific exposure and vulnerability evidence base, combined with Phase 1's hazard projections into revised yield-loss estimates for all seven rainfed crops and a corrected economic-loss estimate for almond (Section 2.3.1). The heatwave workflow is carried forward entirely unchanged from Phase 1.
Stakeholder engagement deepened in Phase 2	Achieved. Nine stakeholder organisations were identified for structured in-depth interviews in Phase 2, building on the 145 organisations contacted in Phase 1. All nine interviews were completed within the reporting period (IMIDA, DG IMAS, DG Industria Alimentaria y Asociacionismo Agrario, Dirección General de Ordenación del Territorio y Arquitectura, FECOAM, AMETSE, the Local Energy and Climate Change Agency of the Ayuntamiento de Murcia, ITREM, and Ecologistas en Acción Región de Murcia, the last completed shortly before submission, ahead of the Phase 3 participatory workshops described in Section 2.6) (stakeholder engagement methodology: Section 2.1.5).
Number of stakeholder meetings and participatory workshops conducted	Achieved, with a scope caveat. Three Technical meeting milestones (M7, M10, M13) were carried out through ongoing UMU–CARM technical meetings (Section 2.5), without individually dated minutes. One stakeholder-facing session was held during the COAST CRAFT Interreg Europe study visit (17–18 March 2026, Section 2.1.5) and met the Phase 2 Participatory workshop milestone (M16), presenting REGMURCIA CLIMAAX to stakeholders and gathering Delphi-informed feedback that informed the Phase 2 interview and survey instruments.
Climate risk assessment report (Deliverable 2) completed	Achieved. Delivered within the Phase 2 timeframe (Months 7–16), including the deepened regionalised risk analysis for river and coastal flooding, the comparison against Phase 1 results and discussion of the resulting discrepancy (Section 2.3.2, 2.4.6), and the revised Phase 3 work plan (Section 2.6).
Dissemination activities, people reached and regional media coverage	None. Phase 2 activities were limited to technical analysis and stakeholder interviews; no press release or media engagement was undertaken during this phase (Section 5).

Key performance indicators	*Progress*
Policy recommendations and sectorial action plans developed	Not yet due. These are Deliverable 3 outputs under the Individual Follow-up Plan, scheduled for Phase 3 alongside the adaptation-measures catalogue and the summary document with prioritised measures, timelines, responsibilities and budgets (Section 2.6).

Table 4-2 Overview milestones

Milestones	*Progress*
Technical meetings (M7, M10, M13)	Achieved, via continuous engagement. Carried out through ongoing technical meetings between UMU and CARM across Phase 2 (Section 2.5).
Participatory workshop (M16)	Achieved. Met through the stakeholder-facing session held during the COAST CRAFT Interreg Europe study visit to the Region of Murcia on 17–18 March 2026 (Section 2.1.5), which presented REGMURCIA CLIMAAX to stakeholders and gathered Delphi-informed expert feedback used to refine the Phase 2 interview and survey instruments.
Second deliverable (M16)	Achieved. Completed and submitted within the Phase 2 reporting period, per the Individual Follow-up Plan.

These results feed directly into Phase 3. The technical-meeting channel established between UMU and CARM is expected to continue informing the methodological reconciliation flagged in Section 5, and the stakeholder base consulted in Phase 2 – together with the participants reached through the COAST CRAFT study visit – forms the starting point for the dedicated Phase 3 participatory workshops on adaptation-measure co-design described in Section 2.6.

5 Supporting documentation

Outputs produced. The outputs produced during Phase 2 are available through REGMURCIA search under https://zenodo.org/communities/climaax:

- D2-REGMURCIA-CLIMAAX_Phase2_CRA_Report.pdf (doi: 10.5281/zenodo.21063451)
  This document presents the Phase-2 Climate Risk Assessment for the Region of Murcia (CARM), developed under the CLIMAAX project. It delivers the regionalized, high-resolution risk analysis for the three priority hazards carried forward from Phase 1 (agricultural drought, coastal and river floods, and heatwaves), together with the updated stakeholder engagement process and the resulting key risk findings. The document consolidates these results into the Phase 2 risk priorities and sets out the work plan for Phase 3.
- SI_Workflow_#1_CropYield_Dashboards_RCP8.5.zip (doi: 10.5281/zenodo.21064524)
  Yield-loss dashboards for seven CARM crops (almond, barley, oats, olives, pistachios, wheat and wine grapes) under the MPI-ESM/SMHI-RCA4 climate model chain for the RCP8.5 scenario. Each dashboard maps projected yield loss (%) for the reference period (2001–2020) and two future horizons (2041–2060 and 2081–2100), together with the corresponding change in yield loss relative to the reference period.
- SI_Workflow_#2_Coastal_flooding.zip (doi: 10.5281/zenodo.21063050)
  Supplementary municipality-level outputs (sea-level-rise sweep panels and damage-composition panels) for the coastal-flooding and sea-level-rise assessment of the Region of Murcia, accompanying Section 2.3.2 of Deliverable 2 (Phase 2 Climate Risk Assessment).
- SI_Stakeholder_Engagement.zip (doi: 10.5281/zenodo.21010861)
  Survey and interview instruments prepared for the Phase 2 stakeholder engagement process. Includes the semi-structured interview guide (Annex – Semi-Structured Interview Guide), the original survey questionnaire (Annex – Original Survey), the pre-Delphi survey draft (Annex – Survey Draft pre-Delphi), the finalised bilingual survey instrument in Word and PDF (Annex – Final Survey, Bilingual), and the quantitative coding matrices of interview responses (Annex – Quantitative Coding Matrices).

6 References

AdapteCCa: Plataforma de intercambio de información sobre adaptación al cambio climático en España, https://www.adaptecca.es, 2025.

del Amor, F. M., Flores, P., Carvajal, M., Martínez, V., Navarro, J. M., and Cerdá, A.: Yield responses of soilless melon and tomato to different irrigation water qualities, Acta Hortic., 333–338, https://doi.org/10.17660/ActaHortic.2001.559.49, 2001.

Andrade, C., Contente, J., and Santos, J. A.: Climate Change Projections of Aridity Conditions in the Iberian Peninsula, Water, 13, 2035, https://doi.org/10.3390/w13152035, 2021.

Anzidei, M., Alberti, T., Vecchio, A., Loizidou, X., Orthodoxou, D., Serpelloni, E., Falciano, A., and Ferrari, C.: Sea level rise and extreme events along the Mediterranean coasts: the case of Venice and the awareness of local population, stakeholders and policy makers, Rend. Lincei. Sci. Fis. e Nat., 35, 359–370, https://doi.org/10.1007/s12210-024-01236-x, 2024.

Barriendos, M., Gil-Guirado, S., Pino, D., Tuset, J., Pérez-Morales, A., Alberola, A., Costa, J., Balasch, J. C., Castelltort, X., Mazón, J., and Ruiz-Bellet, J. L.: Climatic and social factors behind the Spanish Mediterranean flood event chronologies from documentary sources (14th–20th centuries), Glob. Planet. Change, 182, 102997, https://doi.org/10.1016/j.gloplacha.2019.102997, 2019.

Beguería, S., Trullenque-Blanco, V., Vicente-Serrano, S. M., and González-Hidalgo, J. C.: Aridity on the Rise: Spatial and Temporal Shifts in Climate Aridity in Spain (1961–2020), Int. J. Climatol., 45, https://doi.org/10.1002/joc.8775, 2025.

Calafat, F. M., Frederikse, T., and Horsburgh, K.: The Sources of Sea-Level Changes in the Mediterranean Sea Since 1960, J. Geophys. Res. Ocean., 127, https://doi.org/10.1029/2022JC019061, 2022.

Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barret, K., Blanco, G., Cheung, W. W. L., Connors, S. L., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., Jotzo, F., Krug, T., Lasco, R., Lee, Y.-Y., Masson-Delmotte, V., Meinshausen, M., Mintenbeck, K., Mokssit, A., Otto, F. E. L., Pathak, M., Pirani, A., Poloczanska, E., Pörtner, H.-O., Revi, A., Roberts, D. C., Roy, J., Ruane, A. C., Skea, J., Shukla, P. R., Slade, R., Slangen, A., Sokona, Y., Sörensson, A. A., Tignor, M., van Vuuren, D., Wei, Y.-M., Winkler, H., Zhai, P., Zommers, Z., Hourcade, J.-C., Johnson, F. X., Pachauri, S., Simpson, N. P., Singh, C., Thomas, A., Totin, E., Alegría, A., Armour, K., Bednar-Friedl, B., Blok, K., Cissé, G., Dentener, F., Eriksen, S., Fischer, E., Garner, G., Guivarch, C., Haasnoot, M., Hansen, G., Hauser, M., Hawkins, E., Hermans, T., Kopp, R., Leprince-Ringuet, N., Lewis, J., Ley, D., Ludden, C., Niamir, L., Nicholls, Z., Some, S., Szopa, S., Trewin, B., van der Wijst, K.-I., Winter, G., Witting, M., Birt, A., and Ha, M.: IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPC, https://doi.org/10.59327/IPCC/AR6-9789291691647.001, 2023.

Cánovas-García, F. and Vargas Molina, J.: An exploration of exposure to river flood risk in Spain using the National Floodplain Mapping System, Geomatics, Nat. Hazards Risk, 15, https://doi.org/10.1080/19475705.2024.2421405, 2024.

CARM: Estrategia de mitigación y adaptación al cambio climático de la Región de Murcia 2020-2030., Murcia, 2019.

CARM and DGPC: Plan Especial de Protección Civil Ante el Riesgo de Inundaciones de la Comunidad Autónoma de la Región De Murcia (INUNMUR)., Murcia, 166 pp., 2007.

Cataldi, M., Galves, V. L. V., Sphaier, L. A., Garnés-Morales, G., Gallardo, V., Párraga, L. M., Montávez, J. P., and Jimenez-Guerrero, P.: Development of a New Generalizable, Multivariate, and Physical-Body-Response-Based Extreme Heatwave Index, Atmosphere (Basel)., 15, 1541, https://doi.org/10.3390/atmos15121541, 2024.

CEDEX: Impacto del cambio climático en las precipitaciones máximas en España, Madrid, 404 pp., 2021.

CES: Memoria sobre la situación socioeconómica y laboral de la Región de Murcia 2024, Murcia, 228 pp., 2025.

Changnon, S. A., Pielke, R. A., Changnon, D., Sylves, R. T., and Pulwarty, R.: Human factors explain the increased losses from weather and climate extremes, Bull. Am. Meteorol. Soc., 81, 437–442, https://doi.org/10.1175/1520-0477(2000)081<0437:HFETIL>2.3.CO;2, 2000.

Chazarra-Zapata, J., Parras-Burgos, D., Arteaga, C., Ruiz-Canales, A., and Molina-Martínez, J. M.: Adaptation of a Traditional Irrigation System of Micro-Plots to Smart Agri Development: A Case Study in Murcia (Spain), Agronomy, 10, 1365, https://doi.org/10.3390/agronomy10091365, 2020.

CHS: Plan Hidrológico de la Demarcación Hidrográfica del Segura 2022-2027, Murcia, 2023.

CHS: Sistemas Automáticos de Información Hidrológica de la CHS (SAIH), https://saihweb.chsegura.es/apps/iVisor/inicial.php, 2025.

Copernicus: Corine Land Cover 2018. European Union's Copernicus Land Monitoring Service information, https://doi.org/10.2909/71c95a07-e296-44fc-b22b-415f42acfdf0, 2025.

Copernicus and ECMWF: Copernicus Interactive Climate Atlas, https://atlas.climate.copernicus.eu/atlas, 2025.

CREM: Portal Estadístico de la Región de Murcia - CREM, https://econet.carm.es/, 2025.

Doorenbos, J. and Kassam, A.: FAO Irrigation and Drainage Paper 33, edited by: FAO, Rome, 203 pp., 1979.

EEA: European climate risk assessment, https://data.europa.eu/doi/10.2800/204249, 2024.

Eekhout, J. P. C., Millares-Valenzuela, A., Martínez-Salvador, A., García-Lorenzo, R., Pérez-Cutillas, P., Conesa-García, C., and de Vente, J.: A process-based soil erosion model ensemble to assess model uncertainty in climate-change impact assessments, L. Degrad. Dev., 32, 2409–2422, https://doi.org/10.1002/ldr.3920, 2021.

Espín-Sánchez, D.: Superación de umbrales meteorológicos, con tendencia cambiante de los valores extremos, in: Riesgos Ambientales en la Región de Murcia, edited by: Conesa García, C. and Pérez Cutillas, P., Murcia, 59–84, 2017.

Espín-Sánchez, D. and Conesa-García, C.: Spatio-temporal changes in the heatwaves and coldwaves in Spain (1950-2018): Influence of the East Atlantic pattern, Geogr. Pannonica, 25, 168–183, https://doi.org/10.5937/gp25-31285, 2021.

Estrela-Segrelles, C., Gómez-Martinez, G., and Pérez-Martín, M. Á.: Risk assessment of climate change impacts on Mediterranean coastal wetlands. Application in Júcar River Basin District (Spain), Sci. Total Environ., 790, 148032, https://doi.org/10.1016/j.scitotenv.2021.148032, 2021.

FAO: GAEZ v4 Data, https://gaez.fao.org/, 2025.

Garcia-Ayllon, S. and Radke, J.: Geostatistical Analysis of the Spatial Correlation between Territorial Anthropization and Flooding Vulnerability: Application to the DANA Phenomenon in a Mediterranean Watershed, Appl. Sci., 11, 809, https://doi.org/10.3390/app11020809, 2021.

Gil-Guirado, S. and Pérez-Morales, A.: Variabilidad climática y patrones termopluviométricos en Murcia (1863-2017). Técnicas de análisis climático en un contexto de cambio global, Investig. Geográficas, 27, https://doi.org/10.14198/INGEO2019.71.02, 2019.

Gil-Guirado, S. and Pérez-Morales, A.: Inundaciones y sequías en la Región de Murcia: desafíos del cambio global y estrategias para la mitigación del riesgo, in: Informe de riesgos climáticos Región de Murcia 2024, edited by: Conesa Garcia, C., EDITUM, Mjurcia, 127–155, 2024.

Gil-Guirado, S., Pérez-Morales, A., and Lopez-Martinez, F.: SMC-Flood database: a high-resolution press database on flood cases for the Spanish Mediterranean coast (1960–2015), Nat. Hazards Earth Syst. Sci., 19, 1955–1971, https://doi.org/10.5194/nhess-19-1955-2019, 2019.

Gil-Guirado, S., Pérez-Morales, A., Pino, D., Peña, J. C., and Martínez, F. L.: Flood impact on the Spanish Mediterranean coast since 1960 based on the prevailing synoptic patterns, Sci. Total Environ., 807, 150777, https://doi.org/10.1016/j.scitotenv.2021.150777, 2022.

Gómez, J. M. N., Fernández, J. C., Gallardo, J. M., Velarde, J. G., and Rivera, V. V.: Assessment of the Changes in Land Use in the Autonomous Community of the Region of Murcia in the Period 1990–2018, 653–668, https://doi.org/10.1007/978-3-031-20325-1_51, 2023.

Grindlay, A. L., Lizárraga, C., Rodríguez, M. I., and Molero, E.: Irrigation and territory in the southeast of Spain: evolution and future perspectives within new hydrological planning, 623–637, https://doi.org/10.2495/SDP110521, 2011.

Hauer, M. E., Hardy, D., Kulp, S. A., Mueller, V., Wrathall, D. J., and Clark, P. U.: Assessing population exposure to coastal flooding due to sea level rise, Nat. Commun., 12, 6900, https://doi.org/10.1038/s41467-021-27260-1, 2021.

Huizinga, J., De Moel, H., and Szewczyk, W.: Global flood depth-damage functions: Methodology and the database with guidelines, EUR 28552 EN, Publications Office of the European Union, Luxembourg, https://doi.org/10.2760/16510, 2017.

IFPRI: Global Spatially-Disaggregated Crop Production Statistics Data for 2020 Version 2.0. Harvard Dataverse, V4, https://doi.org/https://doi.org/10.7910/DVN/SWPENT, 2024.

Illán-Fernández, E. J., Pérez-Morales, A., Sudmanns, M., and Tiede, D.: Urban heat and soil sealing: A ten-year analysis of temperature dynamics in a semi-arid Mediterranean region, Urban Clim., 63, 102579, https://doi.org/10.1016/j.uclim.2025.102579, 2025.

IPCC: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change., Cambridge University Press., 2022.

ISCIII: Sistema de Monitorización de la Mortalidad Diaria (MoMo), https://momo.isciii.es/panel_momo/, 2025.

Jiménez-Gutiérrez, J. M., Valero, F., Ruiz-Martínez, J., and Montávez, J. P.: Temperature Response to Changes in Vegetation Fraction Cover in a Regional Climate Model, Atmosphere (Basel)., 12, 599, https://doi.org/10.3390/atmos12050599, 2021.

Jones, B. and O'Neill, B. C.: Spatially explicit global population scenarios consistent with the Shared Socioeconomic Pathways, Environ. Res. Lett., 11, 084003, https://doi.org/10.1088/1748-9326/11/8/084003, 2016.

Karrou, M. and Oweis, T.: Water and land productivities of wheat and food legumes with deficit supplemental irrigation in a Mediterranean environment, Agric. Water Manag., 107, 94–103, https://doi.org/10.1016/j.agwat.2012.01.014, 2012.

Kirezci, E., Young, I. R., Ranasinghe, R., Muis, S., Nicholls, R. J., Lincke, D., and Hinkel, J.: Projections of global-scale extreme sea levels and resulting episodic coastal flooding over the 21st Century, Sci. Rep., 10, 11629, https://doi.org/10.1038/s41598-020-67736-6, 2020.

La Opinión de Murcia: La sequía mata a viñedos y almendros de la Región, https://www.laopiniondemurcia.es/comunidad/2024/09/30/sequia-murcia-mata-vinedos-almendros-region-108745786.html, 2024.

Lincke, D. and Hinkel, J.: Economically robust protection against 21st century sea-level rise, Glob. Environ. Chang., 51, 67–73, https://doi.org/10.1016/j.gloenvcha.2018.05.003, 2018.

López-Martínez, F., Gil-Guirado, S., and Pérez-Morales, A.: Who can you trust? Implications of institutional vulnerability in flood exposure along the Spanish Mediterranean coast, Environ. Sci. Policy, 76, 29–39, https://doi.org/10.1016/j.envsci.2017.06.004, 2017.

MAPA: SIGPAC (Sistema de Información Geográfica de Parcelas Agrícolas), https://www.fega.gob.es/es/pepac-2023-2027/sistemas-gestion-y-control/sigpac, 2025.

MAPAMA: Anuario de Estadística, https://www.mapa.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica, 2025.

Martínez-Graña, A., Gómez, D., Santos-Francés, F., Bardají, T., Goy, J., and Zazo, C.: Analysis of Flood Risk Due to Sea Level Rise in the Menor Sea (Murcia, Spain), Sustainability, 10, 780, https://doi.org/10.3390/su10030780, 2018.

Martínez-Valderrama, J.: Desertificación y Cambio climático, in: Cambio Climático en España:, edited by: Notivoli Serrano, R., Olcina Cantos, J., and Martín Vide, J., Tirant lo Blanch, Madrid, 339–368, 2024.

McNutt, M.: Climate change impacts, https://doi.org/10.1126/science.1243256, 2 August 2013.

MECE and CCS: Estadística de Riesgos Extraordinarios (1971-2023), https://www.consorseguros.es/noticias/-/asset_publisher/ya2OdYGgbjgX/content/publicacion-de-la-estadistica-de-riesgos-extraordinarios-1971-2023-, 2025.

MHAC: Difusión de datos catastrales, https://www.sedecatastro.gob.es/Accesos/SECAccDescargaDatos.aspx, 2025.

Ministerio de Sanidad: Plan nacional de actuaciones preventivas de los efectos del exceso de temperatura sobre la salud, Madrid, 55 pp., 2024.

MITECO: Plan Nacional de Adaptación al Cambio Climático, Madrid, 246 pp., 2020.

MITECO: Boletín Hidrológico semanal, https://sede.miteco.gob.es/BoleHWeb/, 2025a.

MITECO: Sistema Nacional de Cartografía de Zonas Inundables (SNCZI), https://www.miteco.gob.es/es/agua/temas/gestion-de-los-riesgos-de-inundacion/snczi.html, 2025b.

MITERD and CARM: PIMA Adapta-MURCIA, https://pimamurcia.ihcantabria.es/visor/#datos, 2025.

MITMA-IGN: Centro de Descargas del Instituto Geográfico Nacional, https://centrodedescargas.cnig.es/CentroDescargas/catalogo.do?Serie=CAANE, 2025.

MITMA: SIOSE AR, https://www.siose.es/siose-alta-resolucion, 2025.

MIVAU: SIU- Sistema de Información Urbana, https://mapas.fomento.gob.es/VisorSIU/, 2025.

Murfin, J. and Spiegel, M.: Is the Risk of Sea Level Rise Capitalized in Residential Real Estate?, Rev. Financ. Stud., 33, 1217–1255, https://doi.org/10.1093/rfs/hhz134, 2020.

MVAU, M. de V. y A. U.: Atlas Digital de las Áreas Urbanas de España, https://atlasau.mitma.gob.es/#c=home, 2024.

ORM: Un 12% de las plantaciones de secano ya se han perdido en la Región de Murcia debido a la grave sequía, https://www.orm.es/noticias-2024/un-12-de-las-plantaciones-de-secano-ya-se-han-perdido-en-la-region-de-murcia-debido-a-la-grave-sequia/, 2024a.

ORM: La sequía pone en riesgo más de 160.000 hectáreas y provoca pérdidas de 146 millones de euros, https://www.orm.es/noticias-2024/la-sequia-pone-en-riesgo-mas-de-160-00-hectareas-y-provoca-perdidas-de-146-millones-de-euros/, 2024b.

ORM: El Gobierno regional activa 4,5 millones de euros para paliar los efectos de la sequía en el almendro, https://www.orm.es/noticias-2024/el-gobierno-regional-activa-4-5-millones-de-euros-para-paliar-los-efectos-de-la-sequia-en-el-almendro/, 2024c.

Peña-Gallardo, M., Vicente-Serrano, S. M., Domínguez-Castro, F., and Beguería, S.: The impact of drought on the productivity of two rainfed crops in Spain, Nat. Hazards Earth Syst. Sci., 19, 1215–1234, https://doi.org/10.5194/nhess-19-1215-2019, 2019.

Pérez-Morales, A., Gil-Guirado, S., and Olcina-Cantos, J.: Housing bubbles and the increase of flood exposure. Failures in flood risk management on the Spanish south-eastern coast (1975–2013), J. Flood Risk Manag., 11, https://doi.org/10.1111/jfr3.12207, 2018.

Pérez Morales, A., Gil Meseguer, E., and Gómez Espín, J. M.: Las aguas residuales regeneradas como recurso para los regadíos de la demarcación hidrográfica del Segura (España), Boletín la Asoc. Geógrafos Españoles, https://doi.org/10.21138/bage.1691, 2014.

Portillo Juan, N., Negro Valdecantos, V., and del Campo, J. M.: Review of the Impacts of Climate Change on Ports and Harbours and Their Adaptation in Spain, Sustainability, 14, 7507, https://doi.org/10.3390/su14127507, 2022.

Romero-Díaz, M. A. and Pérez-Morales, A.: Before, during and after the dana of september 2019 in the region of murcia (Spain), as reported in the written press, Geogr. Res. Lett., 47, 163–182, https://doi.org/10.18172/cig.4769, 2021.

Romero, P., Fernandez-Fernandez, J., and Botia Ordaz, P.: Interannual climatic variability effects on yield, berry and wine quality indices in long-term deficit irrigated grapevines, determined by multivariate analysis, Int. J. Wine Res., Volume 8, 3–17, https://doi.org/10.2147/IJWR.S107312, 2016.

Romero, P., Botía, P., Gil-Muñoz, R., del Amor, F. M., and Navarro, J. M.: Evaluation of the Effect of Water Stress on Clonal Variations of Cv. Monastrell (Vitis vinifera L.) in South-Eastern Spain: Physiology, Nutrition, Yield, Berry, and Wine-Quality Responses, Agronomy, 13, 433, https://doi.org/10.3390/agronomy13020433, 2023.

Sala-Garrido, R., Molinos-Senante, M., Fuentes Pascual, R., Hernández-Sancho, F.: Reutilización de agua: estado actual y perspectivas., Presup. y Gasto Público, 101, 187–204, 2020.

Serrano-Notivoli, R., Beguería, S., Saz, M. Á., Longares, L. A., and de Luis, M.: SPREAD: a high-resolution daily gridded precipitation dataset for Spain – an extreme events frequency and intensity overview, Earth Syst. Sci. Data, 9, 721–738, https://doi.org/10.5194/essd-9-721-2017, 2017.

Sesana, E., Gagnon, A. S., Ciantelli, C., Cassar, J., and Hughes, J. J.: Climate change impacts on cultural heritage: A literature review, WIREs Clim. Chang., 12, https://doi.org/10.1002/wcc.710, 2021.

Sherwood, S. C. and Ramsay, E. E.: Closer limits to human tolerance of global heat, Proc. Natl. Acad. Sci., 120, https://doi.org/10.1073/pnas.2316003120, 2023.

Simón, P. and Oller, I.: Water Reuse in Spain: Drivers and Barriers in Murcia and Almeria Region, 617–641, https://doi.org/10.1007/978-3-031-67739-7_26, 2024.

SIOSE, E. T. N.: Sistema de Información de Ocupación del Suelo en España de Alta Resolución (SIOSE AR): Manual de fotointerpretación, 65 pp., 2021.

Sousa, P. M., Trigo, R. M., Aizpurua, P., Nieto, R., Gimeno, L., and Garcia-Herrera, R.: Trends and extremes of drought indices throughout the 20th century in the Mediterranean, Nat. Hazards Earth Syst. Sci., 11, 33–51, https://doi.org/10.5194/nhess-11-33-2011, 2011.

Spinoni, J., Vogt, J. V., Naumann, G., Barbosa, P., and Dosio, A.: Will drought events become more frequent and severe in Europe?, Int. J. Climatol., 38, 1718–1736, https://doi.org/10.1002/joc.5291, 2018.

Steduto, P., Hsiao, T. C., Fereres, E., and Raes, D.: Crop yield response to water, edited by: Food and Agriculture Organization of the United Nations (FAO), Rome, 505 pp., 2012.

Tang, F. H. M., Nguyen, T. H., Conchedda, G., Casse, L., Tubiello, F. N., and Maggi, F.: CROPGRIDS: a global geo-referenced dataset of 173 crops, Sci. Data, 11, 413, https://doi.org/10.1038/s41597-024-03247-7, 2024.

Tebaldi, C., Ranasinghe, R., Vousdoukas, M., Rasmussen, D. J., Vega-Westhoff, B., Kirezci, E., Kopp, R. E., Sriver, R., and Mentaschi, L.: Extreme sea levels at different global warming levels, Nat. Clim. Chang., 11, 746–751, https://doi.org/10.1038/s41558-021-01127-1, 2021.

Torelló-Sentelles, H. and Franzke, C. L. E.: Drought impact links to meteorological drought indicators and predictability in Spain, Hydrol. Earth Syst. Sci., 26, 1821–1844, https://doi.org/10.5194/hess-26-1821-2022, 2022.

Tuset, J., Barriendos, M., Barriendos, J., Balasch, J. C., Castelltort, X., Gil-Guirado, S., Mazón, J., Pérez-Morales, A., and Pino, D.: Historical flood classification system. Study cases obtained from the AMARNA database (CE 1035-2022), https://doi.org/10.5194/egusphere-egu23-4444, 15 May 2023.

Verschuur, J., Koks, E. E., Li, S., and Hall, J. W.: Multi-hazard risk to global port infrastructure and resulting trade and logistics losses, Commun. Earth Environ., 4, 5, https://doi.org/10.1038/s43247-022-00656-7, 2023.

Vicente-Serrano, S. M., Tomas-Burguera, M., Beguería, S., Reig, F., Latorre, B., Peña-Gallardo, M., Luna, M. Y., Morata, A., and González-Hidalgo, J. C.: A High Resolution Dataset of Drought Indices for Spain, Data, 2, 22, https://doi.org/10.3390/data2030022, 2017.

Vousdoukas, M. I., Mentaschi, L., Voukouvalas, E., Verlaan, M., Jevrejeva, S., Jackson, L. P., and Feyen, L.: Global probabilistic projections of extreme sea levels show intensification of coastal flood hazard, Nat. Commun., 9, 2360, https://doi.org/10.1038/s41467-018-04692-w, 2018a.

Vousdoukas, M. I., Bouziotas, D., Giardino, A., Bouwer, L. M., Mentaschi, L., Voukouvalas, E., and Feyen, L.: Understanding epistemic uncertainty in large-scale coastal flood risk assessment for present and future climates, Nat. Hazards Earth Syst. Sci., 18, 2127–2142, https://doi.org/10.5194/nhess-18-2127-2018, 2018b.

Vousdoukas, M. I., Mentaschi, L., Hinkel, J., Ward, P. J., Mongelli, I., Ciscar, J.-C., and Feyen, L.: Economic motivation for raising coastal flood defenses in Europe, Nat. Commun., 11, 2119, https://doi.org/10.1038/s41467-020-15665-3, 2020.

Yu, Q., You, L., Wood-Sichra, U., Ru, Y., Joglekar, A. K. B., Fritz, S., Xiong, W., Lu, M., Wu, W., and Yang, P.: A cultivated planet in 2010 – Part 2: The global gridded agricultural-production maps, Earth Syst. Sci. Data, 12, 3545–3572, https://doi.org/10.5194/essd-12-3545-2020, 2020.